DOCUMENT RESUME

ED 160 807 08 CE 017 821

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TITLE Guidelines for Planning Industrial Education Facilities and Equipment.
SPONS AGENCY Wisconsin State Dept. of Public Instruction, Madison.
REPORT NO Bull-9167
PUB DATE [74]
NOTE 95p.

EDRS PRICE MF-$0.83 HC-$4.67 Plus Postage.
DESCRIPTORS Building Plans; Design Needs; Educational Environment; *Educational Equipment; *Educational Facilities; Educational Finance; Elementary Secondary Education; Evaluation; *Facility Guidelines; Facility Improvement; *Facility Planning; Facility Requirements; Guidelines; *Industrial Education; Laboratories; Needs Assessment; Reference Materials; Safety; Space Utilization; Spatial Relationship
IDENTIFIERS Wisconsin

ABSTRACT

This guide presents alternatives, resources, and specifications for industrial education teachers to use in preparing a facilities proposal to present to administrators, boards of education, the community, and architects. Developed to reflect the objectives of industrial education as outlined in the "Wisconsin Guide to Local Curriculum Improvement in Industrial Education, K-12," it includes the following topics: (1) criteria for facility planning, emphasizing the students' needs; (2) the objectives of industrial education as identified in the Wisconsin curriculum guide; (3) types of industrial education laboratories; (4) planning sequence for proposing industrial education facilities, from determining design criteria through final evaluation and modification; (5) environment and service specifications, including utility systems; (6) equipment recommendations, according to grade levels; (7) financial sources, such as federal and state aid, bond issues, and leasing; (8) evaluation of existing facilities, containing a checklist for assessing location, space, layout, services, and equipment; (9) modernization of existing structures; (10) shared space concept; (11) alternatives, such as modular structures, mobile units, and remodeling; (12) layouts or floor plans; and (13) the occupational safety and health act as applied to industrial education facilities. Numerous diagrams and charts are interspersed throughout the text and appendixes to illustrate the suggested plans, and a bibliography of reference sources is provided at the end. (ELG)

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GUIDELINES FOR PLANNING INDUSTRIAL EDUCATION FACILITIES AND EQUIPMENT

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CE 017 821

Bulletin No. 9167

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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This Project Was Supported by Funds
Appropriated Under the
Vocational Education Act of 1963
Amended 1968 — P.L. 90-576

Bureau for Career and Manpower Development
Ruel F. Falk, Director

Division for Instructional Services
Robert C. Van Raalte, Assistant Superintendent

Wisconsin Department of Public Instruction
Barbara Thompson, Ph.D., State Superintendent

ACKNOWLEDGMENTS

This Guide would not have been possible without the contributions of the following individuals who gave freely of their time and efforts toward the goal of good planning in the development of industrial education facilities.

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PREFACE

Today is an era of innovation in education. The effect of this pressure for change has been so pervasive that educational leadership in our state has sought to provide assistance to industrial education teachers in implementing curriculum change. This led to the development and dissemination of the new *Wisconsin Guide to Local Curriculum Improvement in Industrial Education, K-12.* It will take several years for the impact of the new guide to be reflected in the schools. In the meantime, decisions regarding new facilities and remodeling of old facilities will continue to be made on the basis of old constructs.

Facilities designed for traditional programs tend to inhibit implementation of new programs and continue to be problems throughout the life of the building unless precautions have been taken in the design stage to provide for flexibility.

This guide is intended to be a companion publication to the state curriculum guide and identifies alternatives, resources and specifications for the teacher to use in preparing a facilities proposal which will communicate his ideas to administrators, members of the board of education, lay persons in the community, and to architects.

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CHAPTER I
INTRODUCTION

Criteria for facility planning

This guide is written for industrial education teachers and teacher educators. It should also be of use to school administrators, industrial education supervisors, members of school boards, architects, and others interested in planning industrial education facilities.

The guide represents ideas, information, suggestions and a beginning for the teacher in the planning of industrial education facilities and equipment. It does not present solutions to specific problems. The ideas suggested follow the objectives of industrial education as outlined in the *Wisconsin Guide to Local Curriculum Improvement in Industrial Education, K-12.*

New criteria for planning industrial education laboratories for today and the future are needed by teachers in the field. Innovations in education are bringing about a great need for change in school facilities. New and changing curriculums, team teaching, modular scheduling, programmed learning, and audio-visual media are all a part of these changes. (15, p 9)

A major responsibility of a teacher is to arrange the learning environment in such a manner as to facilitate learning and to promote optimum educational results. (50, p 195) Thus, every industrial education teacher should continuously strive toward the most efficient arrangement of tools and equipment in the laboratory. While some teachers may never be called upon to design a new industrial education facility or to refurbish an older one, each must face the problem of providing the best possible physical arrangement of the setting in which the learning is to take place.

Sooner or later many industrial education teachers may be faced with the problem of planning or reorganizing an industrial education laboratory. This may range all the way from working with the architect in deciding the size, shape, and general layout for an entirely new laboratory to rearrangement of a room which has seen many years of service as a school shop, or refurbishing a room designed for an entirely different purpose.

In many instances, the industrial education area was designed with traditional and sometimes outdated techniques. Educational facility planning has often been academically oriented. Industrial education has often been allocated insufficient space for an effective and meaningful program. Facilities should be designed according to the program to be implemented within the allocated space.

Shops should be planned for the future so they do not become prematurely obsolete. Improvements in the industrial education areas are needed if challenging curriculums, which will permit students to understand the world of industry and its career opportunities, are to be effectively and efficiently implemented.

The most important element, the student, must not be excluded in the facility planning. It is the student who will be using the facility to better prepare himself for the world of industry. If the student's needs and concerns are not recognized, the basic purpose for which the facility is planned will be defeated. A shop should motivate the student to learn and become aware of what this environment has to offer. It should be a laboratory for learning with action oriented experiences that enable students to understand the relationship of school work to the world in which they live.

Industrial education laboratories are a costly venture in any school system and require careful consideration and planning. A facility should give the most for the financial investment as well as fit the curriculum program and the needs of the students. The cost factor seems to restrict planning because it is felt that more space means more equipment. This should not be the case. The utilization of space and how it will function to reach the objectives of the curriculum should be given more consideration than the cost factor.

Some programs in industrial education emphasize group techniques such as mass production activities and team approaches to solving problems. Therefore, modern facilities should provide for small group activities as well as large group activities and consider the combining of two or more classes working toward a common goal.

Today, new instructional materials and techniques play an expanding role in the educational environment. Many traditional industrial education shops are not designed to properly utilize such techniques as closed-circuit television and multi-media teaching approaches. These techniques need to be included to aid the teacher in effectively presenting some of the curriculum content and improving the teaching-learning process.

Elementary level industrial education facilities should be planned to give students a better awareness of their world which is heavily influenced by industry and technology. At the junior high level, the industrial education facility needs to provide for a wide range of exploratory experiences which become more in-depth at the senior high level. This should be a continuing program, not two or three separate programs. They should compliment each other and form an appropriate sequence for the student to follow.

The comprehension approach will assist in the area of individual differences. The facility must be designed and equipped to allow the student not only to comprehend, but to analyze, synthesize, evaluate, and apply the knowledge.

The facilities should permit an easy transition for the student as he progresses through the curriculum sequence. Since educational events will be varied and often integrated, the facility must be capable of effectively permitting and supporting the necessary activities of the expanding curriculum. The uniqueness of a facility will be in its ability to be modified as new requirements are identified.

It is possible that the laboratory will have to be multi-purpose in nature as it transforms from one type of environment to another. The shop may have several teachers or consultants in the laboratory to supervise the

educational experiences which are necessary to implement certain aspects of a curriculum. A need may arise for the laboratories to be used during the day by students and the community during the evening hours. These extra hours may not be for specific, formal learning but merely open to the community for leisure time activities or to upgrade skills on an individual basis. The facility needs to be a versatile, multi-learning activity laboratory and not a simulated industrial facility. It must be able to respond to whatever setting the curriculum content demands. The students may be working on individual problems, research, working as a team on a problem, or participating in the process of mass production from product orientation to product distribution. The industrial education area for the program of the future must be one where change is not only possible but practical. This approach must provide for change taking place with minimum effort and expense. In order to accomplish this, change must be planned into the facility.

With the expansion of knowledge and the broadening outlook for the purposes of industrial education, the curriculum content cannot hope to be effectively covered unless changes can be incorporated into new and existing facilities. The rapid growth of the technology of automation is another force which is shaping the direction of change. The increasing number of job titles with new functions and a need for new competencies and knowledge is bringing a need for new learning environments and new uses of present environments. Students must be educated to be ready and able to cope with new occupations. This means establishing an environment which will make the student aware of his future needs. This cannot be accomplished effectively working in only two or three areas of concentration. This is why it is important that a conceptual structure of the curriculum be developed along with a facility that permits the student to be aware of the many elements of industry. The facility should supplement and compliment the curriculum content by enabling the student to interrelate areas of concentration and move freely about the entire industrial education complex.

Laboratories in an industrial education department cannot be thought of only as individual areas of concentration but as one large area available to the student's needs and demands. The areas may be merely divided by work modules or by portable or powered foldable walls to divide processing areas from production or construction areas. A student may carry on independent study in a flexible environment which permits him freedom to move from process to process, material to material or wherever is needed to complete his study. Independent areas may be established as departments within an industry and become integrated into a complete production problem by merely opening up the available space. Areas need also be flexible enough to permit in-depth concentration where the curriculum program is designed for upper levels of the total industrial education program.

Real changes in the laboratories can come with better utilization of present space and equipping the laboratories with those elements which will enable the student to better understand and experience the world of industry. The space concept implies that versatility and flexibility are the important features to be considered in planning procedures. The main point is that space should be subject to changing conditions and lend itself to a rearrangement of machines, tools, services and work stations. Space should be economically adapted to curriculum changes and capable of serving many functions. Space is not merely an end in itself but must be looked on as a means to a larger end with the intention of promoting the well being and increasing the productivity of its occupants. The facility should function and operate according to learning content and activities. It must be functional and utilized to its maximum in order to provide a good educational environment.

Time and effort spent in carefully planning industrial education facilities will bring rewards of more effective industrial education teaching and learning. Program and facility go together. Facility to the industrial education program is like the chemistry laboratory to the chemistry program or a gymnasium to the physical education program. Without the proper facility the program is likely to be limited and restricted. Limitations in space for industrial education cannot be afforded if it is expected to maintain a complete industrial education program which will meet the objectives of the industrial education program.

CHAPTER II
OBJECTIVES OF INDUSTRIAL EDUCATION

Industrial education, throughout its history, has encountered many problems regarding its direction. In recent years there have been a multitude of different programs rising to the surface in the field of industrial education. Each of these new programs has merit and, in principle, they all seem to be aimed toward a common goal or philosophy of industrial education. They are concerned with the direction of industrial education in meeting the needs of the youth of tomorrow's world. Many of them have brought about changes in the thinking of industrial education teachers. These changes are being implemented across the United States.

The objectives of industrial education have not changed drastically over the years. The understanding of industry has been an objective since 1938 when it was listed by Gordon Wilber. (46, pp 42-43) It continues to be considered an objective by most people in the field as shown by more recent publications from the American Vocational Association. (48 & 49)

Industry as a dynamic element in our society serves as an institution developed by man to meet his material needs. As the society in which we live changes due to the industrial and technological culture, so do the needs of our youth change. Students should be oriented to change before they are thrust into the world. People are constantly being affected by the goods and services produced by industry either as workers, suppliers, or consumers. The influence of industry on people, their environment, life styles, and even values, is pervasive, but often times subtle. The average person does not really know or understand a great deal about the impact of industry on human beings, whether it be positive or negative. Many persons working in industry do not understand industry as a whole, but only their own specific jobs.

Industry effects the lives of people in that it provides goods and services and gives many the means of earning a living. Industry is such a dynamic force in a technically oriented, contemporary society that it is important for all citizens to understand it. Industrial education is the major field of study through which this understanding becomes possible. Students may learn about different facets of industry on a low level through other courses of study but there is no other single subject which attempts to develop an in-depth understanding of industry. Industrial education can and must accept this challenge if it is to help the young people live in today's world.

"Industrial education is that segment of education which draws its body of content from industry. It provides for a comprehensive understanding of this societal institution as well as the development of competencies related to various elements of industry." (1, p 3) A comprehensive industrial education program will involve a study of the total institution of industry. It will deal with the multiple elements which make up industry and the ways in which they interact. In providing the opportunity to experience these many elements of industry the student will need to develop competencies for entry into the world of work and to become acquainted with a wide variety of career opportunities found in industry today.

The objectives of industrial education as stated in the Wisconsin curriculum guide are as follows: (1, p 3)

To provide students the opportunity:

To work with elements of industry to gain understanding of how they function in producing goods and services.

To understand the interdependence of society and industry.

To explore the context in which industry has developed and continues to develop.

To explore occupational areas as a basis for selecting a career and understanding the pursuits of others.

To prepare for entry into appropriate industrially related occupations and develop a base for further occupational education.

The Wisconsin curriculum guide suggests an interrelationship of industrial areas. A total program should include instruction in as many facets of industry as feasible. These areas should not be dealt with separately but should be interrelated so that the student can gain a better insight into industry. For example, Communications suggest combining the areas of drafting, graphic arts, photography, and electronic communications to form content concerning visual communications, audio communications, and audio-visual communications. Other areas of concentration are Power and Energy, Transportation, Manufacturing, Construction, and Materials and Processes. Facilities and instructional methods should be flexible enough to provide for experiences which involve the interrelationships between the aspects of industry.

With the above objectives in mind, teachers and curriculum supervisors must begin to select curriculum content and design learning experiences which relate to these objectives. As the eleven elements of industry, as outlined in the state guide, are studied, it must be determined which types of physical environment will promote and integrate these elements into a total industrial education curriculum. (1, p 4)

An existing physical facility may be adequate in relationship to the objectives and elements of industry. However, it may merely mean a different instructional technique to be used in the present facility to implement the understanding of industry. Present facility space may be reorganized to bring about a better environment for teaching the elements of industry. When planning a new facility, the elements of industry and learning experiences must be developed into a learning environment.

It is absolutely necessary that the philosophy, objectives, and curriculum be carefully considered before proceeding with an orderly planning of industrial education facilities.

CHAPTER III
TYPES OF INDUSTRIAL EDUCATION LABORATORIES

Although we are currently seeing a trend toward combining areas of industrial education, there are three distinct kinds of industrial education laboratories commonly used in schools. They are the comprehensive shop, general unit shop, and the unit shop. Each of these has its place and purpose in industrial education.

Comprehensive shop.

The comprehensive shop is one which is designed and equipped to permit instruction in four or more areas of curriculum concentration within one room. The size of the room may vary to permit supervision by one or two instructors depending on the number of students. It is recommended for small schools having only one shop. It is designed to permit broad, exploratory work in several major industries. Major areas of concentration recommended for a comprehensive shop are manufacturing, construction, communication, and power. Each of these major areas may be further subdivided. This type of shop is more useful at the junior high school level because courses are primarily exploratory and may not include many in-depth experiences.

General shop.

The general shop is planned and equipped to permit instruction in two or three areas of curriculum concentration within one room. Areas are planned so that activities may be carried on and explored in reasonable depth. It would be recommended for a large junior high school or small senior high school with more than one shop. Each shop would be general in nature, such as a materials and processes laboratory where manufacturing and/or construction could take place, an energy laboratory, and a communications laboratory. This arrangement would permit exploratory experiences in a rotating program from one general shop to another during the school year or could possibly be utilized for in-depth content on a semester or year course schedule.

Unit shop.

The unit shop is one which is designed and equipped for in-depth instruction in one area of curriculum concentration. It is recommended for a senior high school which has a large enrollment justifying four or more shops. Examples of the unit shop would be a manufacturing laboratory, construction laboratory, communications laboratory, and an energy laboratory. The unit shop should be so planned as to enable the student to develop a relative depth of experience within one curriculum area of industrial education. The unit shop is the least effective of the three types in the accomplishment of the overall objectives of industrial education. These facilities are closer to providing experiences related to vocational "capstone" programs at the upper grade levels in high school.

With the current trend toward the combining of various areas in industrial education, it becomes possible to combine laboratory styles to give the best possible facility in which to implement a program. A space may be large enough to permit sub-dividing by means of foldable walls, as long as building codes are maintained, to provide comprehensive laboratories or unit laboratories. For example, a materials and processes laboratory (comprehensive) may be sub-divided to give unit shops in manufacturing or construction. When sub-divided it permits in-depth activities to be carried out. An energy laboratory may be sub-divided into unit shops concentrating in areas such as fluidics, engines, mechanical, or electrical. A communications laboratory (comprehensive) may be divided into unit shops containing visual or audio communications.

It is therefore extremely important that the program and its activities be identified before beginning facility planning. Curriculum planning determines the nature and depth of the program so the proper facility may be designed and equipped to give the student the best possible opportunity to learn about industry.

CHAPTER IV
PLANNING SEQUENCE FOR PROPOSING INDUSTRIAL EDUCATION FACILITIES

The curriculum planning sequence cannot be overly stressed because it becomes the key to a successful facility plan. It is applicable to new facilities or the modernization of existing facilities. The costs for poorly planned facilities cannot be retrieved and may well be a disadvantage to the school system for years. Even when the original design is good, continuous evaluation and reorganization should be considered.

It is essential to establish a local industrial education program planning committee before a facility plan can be started. This committee should be composed of industrial education teachers, local supervisors, local administrators, and state or university consultants. Everyone should be well aware of the local school situation and be provided with reference materials which will aid in the planning. There should be such information as state accreditation standards, related local and state laws and regulations, school philosophy and goals, outline for preparing educational specifications, trends in industrial education, and estimated construction and equipment funds available.

The industrial education committee should develop a network analysis complete with a time schedule so that necessary tasks may be performed in sequence and on time.

There exists an identifiable procedure used by plant engineers and industrial designers which may be applied to the designing of industrial education facilities. There are two distinct phases in the facility planning process—Phase One, in which the proposal is made ready for approval and Phase Two, in which the approved proposal is transformed into detailed drawings, construction, and equipment acquisition. The industrial education teacher's contribution is essential during Phase One and is advisory during Phase Two.

With this in mind a logical planning sequence may be outlined as follows.

Phase One

1. Determining design criteria.
2. Educational specifications.
3. Transmittal of information to architect.
4. Preparation of preliminary layouts.

Phase Two

5. Completion of detailed layouts.
6. Construction.
7. Acquisition of equipment and materials.
8. Installation of equipment.
9. Evaluation and modifications.

Determining design criteria.

A widely stated, but often violated, principle of facility planning is that the facility should be developed to accomplish the objectives of the program. Decisions concerning philosophy, goals, and instructional program to be implemented must be made during this step of the planning sequence. The philosophy must be written in such a way that it communicates to others the real direction intended for the industrial education program. This philosophy should parallel the school's philosophy and the philosophy of industrial education within the state.

The next step in planning the design criteria is to establish objectives for the program. Objectives should be written for the elementary and secondary levels to provide a totally coordinated program. These objectives become obligations which the program assumes and promises the student and the public what will be studied and for what purposes. The objectives should be clearly written so they are understood by students, teachers, and the public. The objectives for industrial education in the State of Wisconsin should parallel those referred to in Chapter II of this guide.

When writing objectives for a program in a designated school, special factors concerning the needs of the students and the nature of the community need to be considered. It may be worthwhile to conduct a survey of the needs of the students and community.

Scope and sequence.

It is necessary at this time to begin establishing the scope and sequence of the industrial education courses to be offered in the school district. The total sequence adopted by a school district depends on many state and local school factors. Consideration must be given to philosophy, goals, characteristics of the community and students, potential student enrollment, space allocation, funds, and other available resources. The scope and sequence of the program should be developed into a matrix showing the total course offerings from elementary through secondary school levels.

Careful thought and research is necessary to effectively evaluate and study the current scope and sequence of courses being implemented around the state and nation. The current emphasis of industrial education's role in career education and comprehensive vocational programs is stimulating a new approach to the organization and sequence of course offerings. Course titles emphasizing manufacturing, construction, energy, communications, and materials and processes are frequently being implemented within the industrial education curriculum. Local needs may require courses which emphasize other areas of industry and technology.

The combination of desired courses and potential student enrollments will have considerable bearing on the

SCOPE AND SEQUENCE OF INDUSTRIAL EDUCATION

Elementary (1-6)	Middle School (7-8)	Senior High (9-12)	Post Secondary
AWARENESS OF INDUSTRY	ENERGY	ENTERPRISE	
Working with tools and materials	MANUFACTURING	CONSTRUCTION	
EXPLORATION	COMMUNICATION	ENERGY	VOCATIONAL-TECHNICAL EDUCATION
Exploring self and occupational opportunities	STUDY OF INDUSTRY	MATERIAL PROCESSING	WORKING WORLD
	CONSTRUCTION	COMMUNICATIONS	COLLEGE OR UNIVERSITY
	MATERIALS AND PROCESSES	PRODUCTION	
		TRANSPORTATION	

FIGURE 1

Matrix of industrial education courses showing scope and sequence. All courses listed would not necessarily be offered but they are the possible alternatives for a program.

number of laboratories and size of each laboratory. See Figure 1 for an example of a scope and sequence matrix.

Once the course levels and sequences have been established, a description and brief outline of each course to be offered in the program may be developed. The content outline will be a guide to selecting activities and equipment. It will also aid in determining space allocation, number of teachers required, and scheduling of courses.

Educational specifications.

After the desired instructional program has been defined, it becomes necessary to begin the more detailed aspects of the planning sequence. Educational specifications are detailed descriptions and standards which may serve as a basis for facility planning decisions.

A complete written description of the facility requirements must be provided as a vehicle of communication between the educator, administrators, and the architect. This will give the architect a rationale on which to base his design. Justifiable statements describing the needs should be written for such items as, space needs, space relationships, color schemes, lighting, electrical, exhaust, acoustical, and communication systems. (See Appendix A for a suggested format to use for educational specifications.)

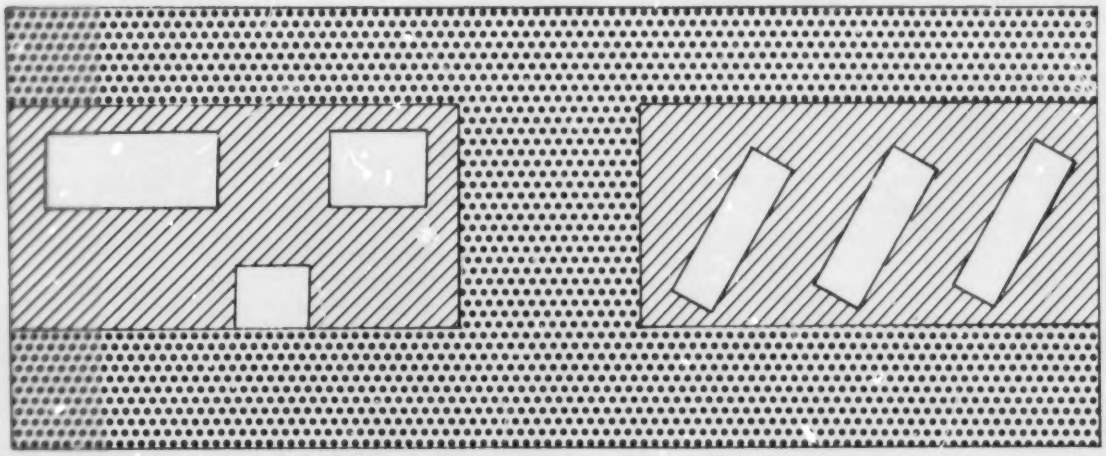
Educational specifications are a critical part of the planning process. The more detailed and complete they are the more likely they will serve as a useful tool to the architect. The architect will be able to transfer these specifications into a preliminary layout with a minimum of design changes. Change orders are many times difficult to implement once construction has begun. Compromises and size reductions may have to be made but not without full knowledge of their effect on programs. Having educational specifications which are complete provides the best defense when compromises and reductions must be made.

Space needs.

After the desired instructional program has been defined and scope and sequence of courses planned out, it becomes necessary to begin estimating space needs. Factors such as school enrollment, industrial education enrollment, class size, number of class sections, courses required or elective, availability to boys and girls, amount of equipment, and student/teacher activities to be implemented must all be weighed in determining space. Each school system is different and it is necessary to estimate space according to the local conditions. There is both a minimum and maximum laboratory size and plan within which a program can, from an educational viewpoint, operate efficiently.

Some systems use a figure of 25 per cent of the school membership to determine the number of students which will elect industrial education courses and a square foot space allowance for each student in the laboratory. Example: materials and processes laboratory, 100 square feet per student X 20 students = 2000 square feet. Others use the formula: total area of laboratory = (area for basic system + area per student station) X number of students. This formula suggests that regardless of the number of students in a laboratory space is needed for the basic equipment to teach the program.

There are three basic space requirements which should be considered. They are: (1) station allowances — space for basic machines, teaching systems, work area for students around the machines, and a minimum of safety clearance; (2) station circulation burden — general circulation allowance within that area of the laboratory containing stations, such as aisle space and traffic patterns; (3) general circulation — space allowance for general support facilities, such as clean up and future expansion. This last space category usually amounts to about 25 per cent of the total of (1) and (2). (3, p 11) See Figure 2 for an example of this space breakdown.



Basic Station

Station Circulation Burden

General Circulation Burden

FIGURE 2

Three basic space requirements to be considered when estimating lab space.

The following space allocations are recommended as ideal minimums for an optimum industrial education program. They are based on twenty-four students per class. All laboratories listed should not be interpreted as meaning they should exist in all programs but merely are given as alternatives. They very well may be combined in some cases, particularly for smaller schools, thereby reducing the total area required.

Junior High School

Manufacturing laboratory

Main processing area	1500	sq. ft.
Material storage	600	
Student project storage	400	
Finishing room	150	
Small equipment storage	150	
Total	2800	sq. ft.

Materials and Processing laboratory

Main processing area	1500	sq. ft.
Material storage	600	
Student project storage	400	
Finishing room	150	
Small equipment storage	150	
Total	2800	sq. ft.

Communications laboratory

Visual communications area	1500	sq. ft.
Audio communications area	900	
Darkroom	150	
Storage areas	300	
Total	2850	sq. ft.

Power/Energy laboratory

Mechanical work area	600	sq. ft.
Electrical work area	600	
Fluidics area	600	
Propulsion area	600	
Storage areas	400	
Total	2800	sq. ft.

Construction laboratory

Fabrication and installation area	1800	sq. ft.
Design and development area	300	
Storage areas	600	
Total	2700	sq. ft.

Multi-purpose room (classroom, media)	900	sq. ft.
Office area (per teacher)	100	sq. ft.

Senior High School

Power/Energy laboratory

Mechanical energy area	800	sq. ft.
Electrical energy area	800	
Fluidics area	800	
Propulsion systems area	1500	
Storage areas	600	
Total	4500	sq. ft.

Communications laboratory

Visual communication systems	1500	sq. ft.
Audio communication systems	900	
Audio-visual systems	600	
Darkroom	150	
Radio Ham station room	50	
Storage areas	600	
Total	3800	sq. ft.

Materials and Processing laboratory		
Machine processing area	3000	sq. ft.
Finishing room	200	
Material storage	300	
Project storage	300	
Total	3800	sq. ft.
Manufacturing laboratory		
Fabrication area	2500	sq. ft.
Production, planning area	500	
Assembly area	400	
Finishing room	200	
Storage areas	500	
Total	4100	sq. ft.
Construction laboratory		
Fabrication area	2000	sq. ft.
Erection area	1000	
Design area	500	
Storage areas	600'	sq. ft.'
Total	4100	sq. ft.
Multi-purpose (classroom, media)	900	sq. ft.
Office area (per teacher)	100	sq. ft.

Equipment

It is essential that equipment lists and equipment layouts become a part of the specifications so the architect has some idea of proposed mechanical requirements and design layout features to be desired in the preliminary layouts. While it is not necessary to list hand tools and pieces of equipment which will be stored in cabinets, it is necessary to list all those items which require floor space. The equipment list should be separated by rooms and by fixed or movable categories. Information needed for each piece of equipment is the floor space required and utilities required. It is not as detailed as required for requisitioning, but must be sufficient to provide the architect enough information for effective layout and to provide for adequate and safe operating space. It will also provide the architect with information regarding flexibility and location of utilities necessary for the laboratory.

The following is an example of the equipment list. (A more complete recommended equipment list for various areas is found in Chapter VI of this guide.)

Materials and Processes Laboratory

Fixed equipment:	Floor space
1 - Speedy melt crucible furnace ½ HP motor, 110 volt, 225,000 BTU, 1″ gas line w/½″ valve	8′ x 8′
Movable equipment:	**Floor space**
1 - Wood surfacer 18″ 5 HP motor, 3-phase 208-220/440 volt, magnetic starter, 775 cfm dust collection	6′ x 20′
1 - Drill press, 15″ (floor model) ¾ HP motor, single phase, 115/230 volt, magnetic starter.	3′ x 3′
1 - Work bench (metal base w/wood top)	8′ x 8′

Auxiliary spaces.

These spaces include storage for tools, materials and projects as well as finishing rooms, darkrooms, and office space. Each of these spaces should be planned separately but in relationship to the main laboratory.

When designing a new facility there are many items of storage which may be built-in and the cost absorbed in the building contract. For example, a darkroom sink or fixed lumber racks should be included in the cost of construction and not taken from the equipment budget.

There are many methods of storing supplies, tools, and student projects. Some prefer large bins with lockable doors and others prefer open shelving. Each planner must determine the type and amount of such space that will be desirable.

Specifications for each auxiliary area should be very explicit and include all necessary accessories, such as lighting, electrical, ventilation, exhausting, built-in features, shelving, and built-in cabinets.

An instructional classroom and resource center should be planned within or near the industrial education department. It should be adjacent to the main work areas for easy access and partitioned preferably with partial glass walls for proper supervision. Proper layout can make the instructional area accessible to several main work areas.

In smaller schools where less sections are scheduled, the classroom may be designed as a multi-purpose room. It may serve as a planning center, resource center, technical library, and may be used for small group discussions as well as a classroom. Normally, this area may have a lower ceiling height providing a mezzanine for potential storage overhead.

When a separate classroom or multi-activity room cannot be provided, provision must be made in the main work area for classroom activities. This includes seating and suitable writing surfaces for the students as well as audio-visual and demonstration capabilities.

Storage areas should be adjacent to, but separated from, the main work area and designed to form a related part of the total laboratory. Large storage areas should be provided for such materials as lumber, metal, plywood, sheet metal, hardboard, and plastics. Doorways into storage areas must be positioned correctly so the materials may be moved in and out easily. This positioning is also related to the location of vertical or horizontal racks to be used inside the room. The number of racks will be determined by the quantities of materials needed during the year. These rooms should also be located near where deliveries are made and close to the first processing operations to eliminate, as much as possible, material handling.

Student project storage must also be considered. This may be bench locker units where the items to be stored are generally small in size. For larger projects, it is necessary to plan either open storage bins or locked bins for safe storage.

Adequate storage space is often overlooked in the basic planning, resulting in sacrificing valuable laboratory work space for storage which may cause a safety hazard in the laboratory.

A finishing room, free of dust, should be provided adjacent to the main laboratory work area. It is recommended that a window or a door with a window be provided, so the instructor can supervise the area. It is extremely important to check local fire regulations and building codes regarding requirements for a finishing room. These codes usually require explosion proof electrical fixtures and exhaust fans ducted to the outer atmosphere. A filtering system should be provided. Fire resistant finishing cabinets must be used for storage of all flammable liquids. In some cases, only a limited amount of flammable or combustible liquids may be stored in the finishing room. A fire extinguisher must be located within ten feet of the door leading into where these liquids are stored. If a spray booth is provided it must meet the regulations and be properly filtered and connected to an exhaust system. For safety reasons, the fume exhaust on the spray booth should

have an automatic cut-off when the cubic feet per minute drops below an unsafe level. Also it is recommended that an automatic sprinkler system be installed in the finishing room. It is also a good idea to provide drying shelves or racks.

The office area should provide a space for the instructor to plan and organize the instructional program. It should also be semi-private for counseling of students. It is preferred that the offices be located near the laboratory for easy access to needed materials, although some instructors prefer their offices to be more isolated. The office should be equipped with a desk, chair, planning table, file cabinets, bookshelves, and a telephone.

Environmental considerations.

The environmental considerations to be included in the educational specifications are the visual, auditory, ventilation, interior structure, and utilities. Because of the importance of the environmental features, more specific information will be given in Chapter V of this guide.

Space relationships.

The size of spaces and the types of spaces to be included within the facility have been discussed earlier. The shape of the spaces and their relationships to each other, and to other areas of the school, are equally important. The shape may vary from square or rectangular to other geometric shapes, but more important are maximum efficiency in traffic patterns, safety, clustering of areas, flexibility, and good supervision. Any shape which does not permit complete visibility for the instructor from any position in the laboratory should be avoided.

The planning committee should not submit a recommended layout to the architect but only indicate relationships and sizes of spaces using bubble diagrams or space relations diagrams. (See Figures 3, 4 & 5.) These diagrams should illustrate the relationship of the industrial education department to other areas of the school, relationchips of each laboratory to each other, and the relationships of auxiliary areas within each laboratory. The architect will have the responsibility of interpreting the

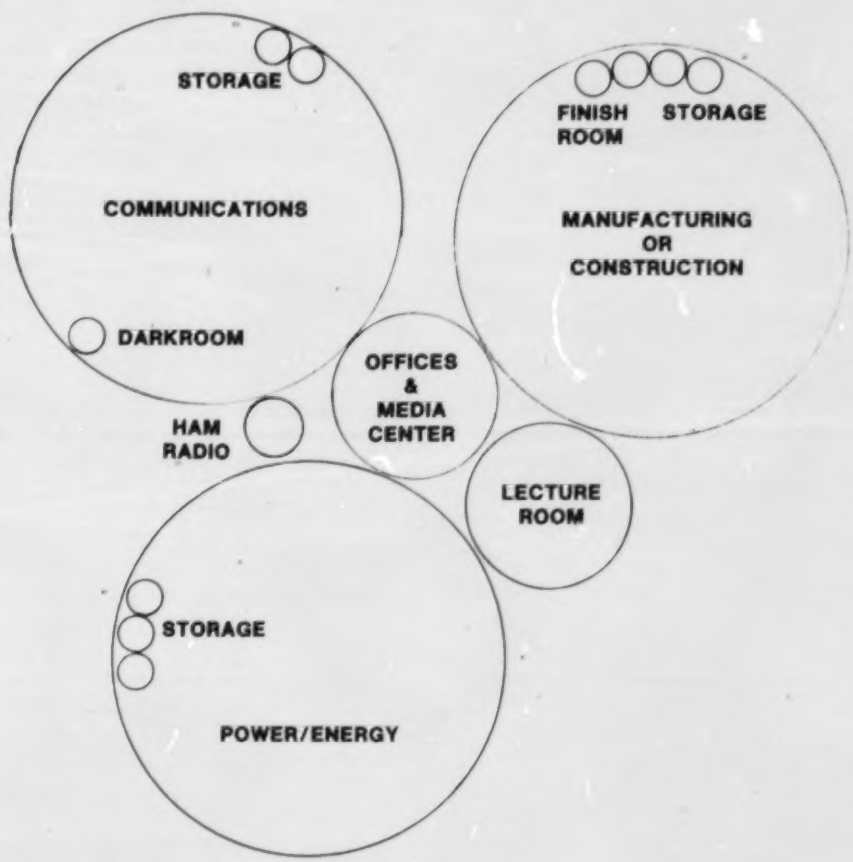


FIGURE 3

Space Relations Diagram for an Industrial education complex.

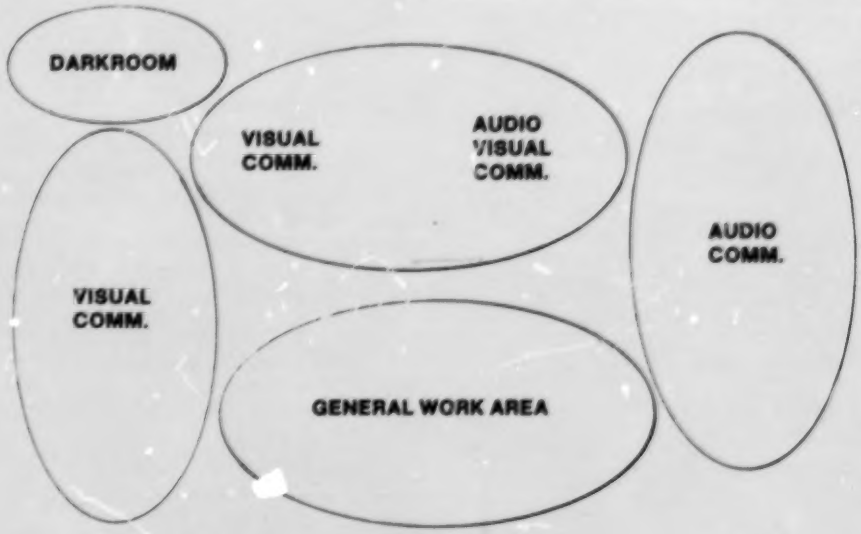


FIGURE 4

Space Relations Diagram for a Communications area.

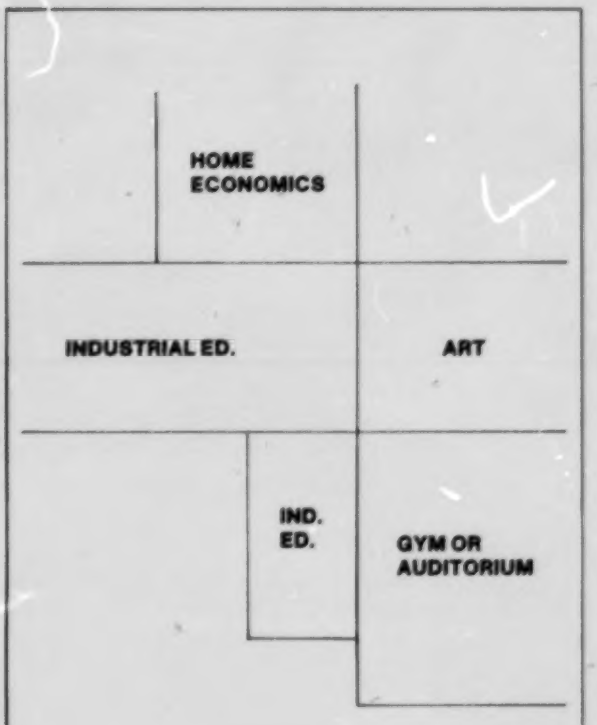


FIGURE 5

Space Relations Diagram showing the location of Industrial Education in the school.

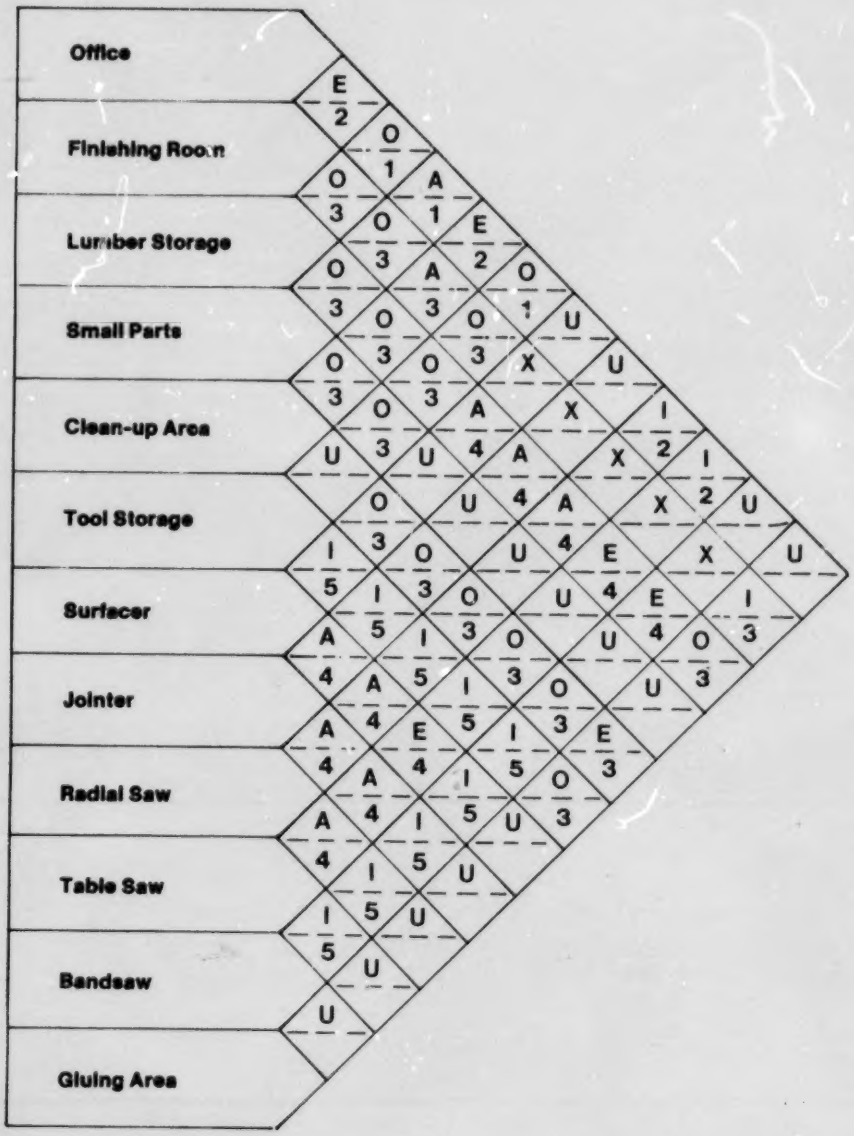
specifications and providing preliminary layouts showing the relationships in more detail. Teachers can assist in placement of equipment following the approval of the preliminary layout of the laboratories.

Individual laboratories within the industrial education complex should be placed in positions for the best physical arrangement and most effective intradepartmental activities. Layout should be such that it is not necessary to pass through one laboratory to get to another. When adding to an exising structure or remodeling, it is necessary to work around existing limitations. The existing structure may not have the right configuration or a hallway may have to divide areas due to the necessity for fire exits. However, an attempt should be made to maintain a good working relationship between the various areas of the department and the school.

The industrial education department is an integral part of the total school building and should be designed this way. It is normal to position the laboratories on the perimeter of the building because of material deliveries, the need for large overhead doors, and sound control but they should not be designed as an appendage to the main school building. As an integral part of the educational program, they should be easily accessible to other areas of the school so interdepartmental activities may be implemented.

Relationship chart.

The relationship chart, used by plant engineers, is a technique used to establish closeness of laboratories, auxiliary rooms, areas within a room, and equipment layout. (An example of a relationship chart is found in Figure 6.) The relationship chart not only illustrates relationships but rates the importance of the closeness between laboratories, areas, or pieces of equipment. Each closeness rating is justified with a reason. It provides for a one to one comparison on their relationship.



VAL.	CLOSENESS
A	Absolutely Necessary
E	Especially Important
I	Important
O	Ordinary
U	Unimportant
X	Undesirable

CO.	REASON
1	Control
2	Supervision
3	Convenience
4	Material Handling
5	Processing

FIGURE 6

Relationship Chart

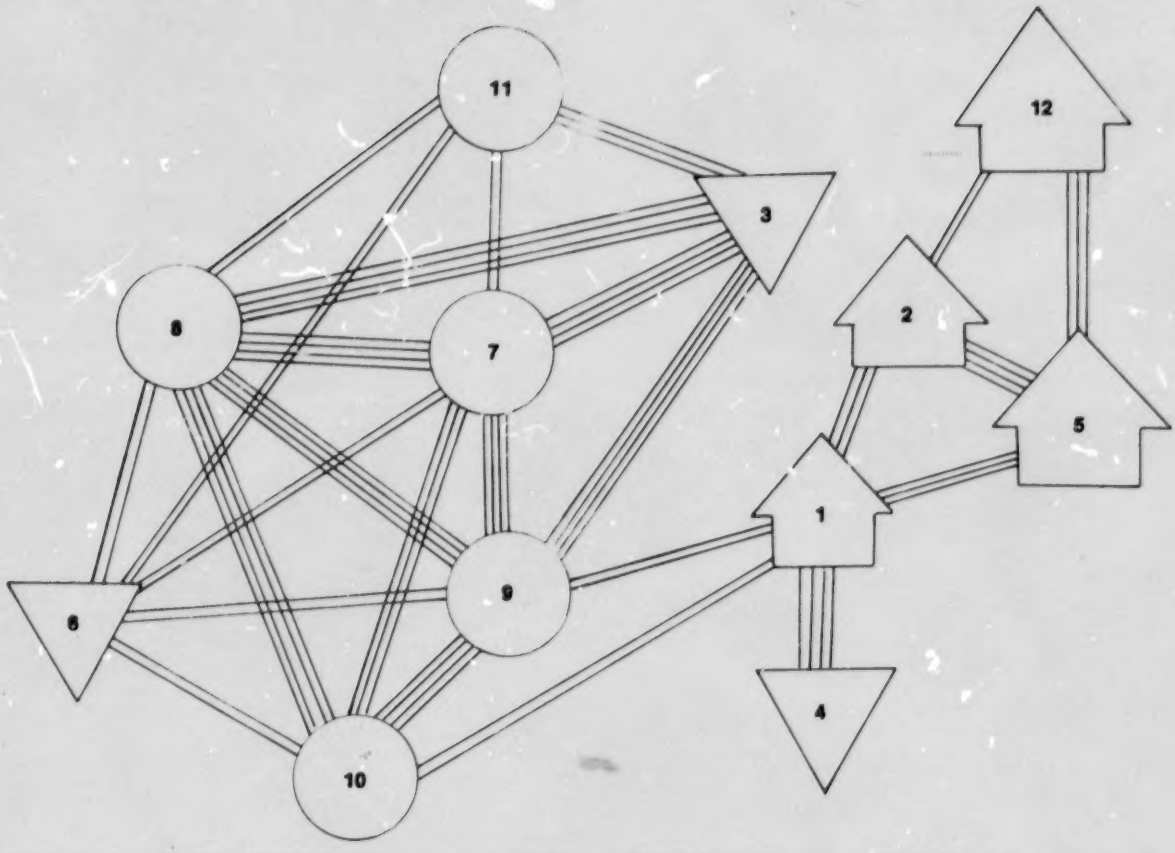


FIGURE 7

Flow and/or Activity Relationship Chart showing placement of areas by closeness.

Each box is divided horizontally so that in the upper half is recorded the closeness rating value and in the lower half is recorded the reason for each relationship. (12, p 5-5) Where the element on down-sloping line #1 (Office) intersects the element represented by up-sloping #3 (Lumber storage), the relationship between element #1 and element #3 is recorded. In this case it was a 0/1 meaning Ordinary closeness and reason being Control. In this way, there is an intersecting box for each pair of elements involved. This one to one matrix lessens the degree of complexity.

The information on the relationship chart can be used to form a flow and/or activity relationship diagram. This provides a visual picture of the data from which a layout pattern begins to develop. (See Figure 7 for an example of the flow and/or activity diagram.) The line code used between elements illustrates the closeness values shown in the relationship chart. Four lines indicates closeness as absolutely necessary, three lines indicates closeness as especially important, two lines indicates closeness as somewhat important, and one line indicates closeness is not particularly important. (12, pp 6-6) This procedure permits an easy transposition of the flow and/or activity diagram to an equipment layout when the preliminary plans are completed by the architect.

Equipment location.

Once the architect has completed preliminary plans showing position and size of spaces to be included, placement of equipment may begin. This is especially important to the architect so he can visualize where the mechanical services are going to be needed throughout the facility.

Machines and work areas must be properly positioned to allow a normal sequence of operations with a minimum of cross traffic. Movable equipment will aid in proper positioning and in special problem activities such as production lines. Semi-permanent positioning of the equipment will enable proper positioning of electrical bus ducts, exhaust systems, air lines, and lighting. Generally, since materials move from storage to machines for sizing, to bench fabrication or processing, to finishing, this order should be followed for proper layout whenever feasible. Machines must be positioned to permit safe operator space, material handling, and maintenance. Direction of

lighting should be considered so shadows on the working surfaces are at a minimum. Sufficient aisle space between machines, so traffic flow does not interfere with machine operations, should be provided in the layout.

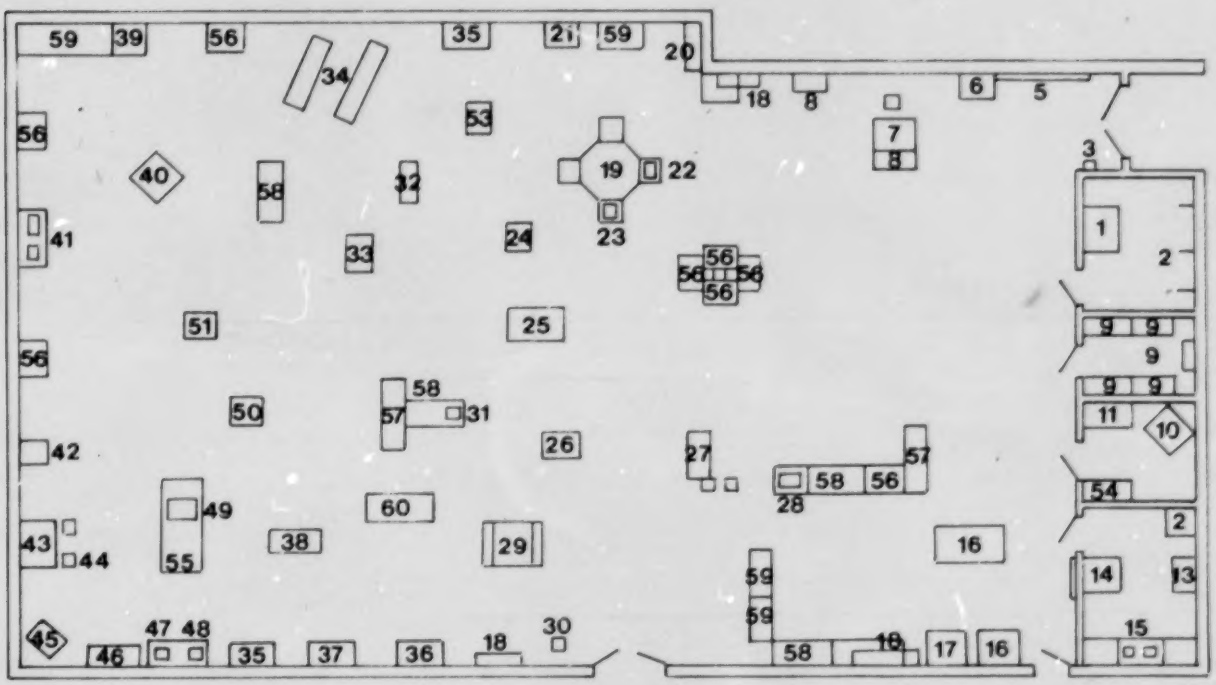
The use of scale model equipment or templates can be very helpful in determining the optimum arrangement of the laboratory equipment. (See Figure 8 for an example of an equipment layout.)

Transmittal of information to architect.

All specifications regarding the project should be submitted to the architect. A meeting should be arranged between the architect, administrators, and planning committee to discuss questions concerning the specifications. This will permit a complete understanding of the specifications before progressing into preliminary layouts.

Preparation of preliminary layouts.

The architect incorporates the specifications submitted by the facility planning committee into a well designed structure by attempting to blend the recommended design features together into a well-planned facility. These preliminary layouts may provide alternative plans from which the planning committee may make a decision as to which will best serve the school. It is during this stage that changes should be made as the committee reviews the layouts submitted by the architect. Later changes, after construction begins, should be avoided whenever possible. As the facility planning committee reviews the layout, they may suggest changes in the placement of such items as doors, windows, partitions, drinking fountain, wash sinks, clocks, power boxes, and columns. These changes would be primarily for better equipment placement.



1. Vert. metal storage
2. Horl. lumber storage
3. Time clock
4. Chalkboard/screen
5. Bulletin board
6. File cabinets
7. Desk & chair
8. Display cabinets
9. Storage cabinets
10. Spray booth
11. Finishing cabinet
12. Refrigerator
13. Enlarger, photo
14. Vert. camera
15. Sink
16. Drafting tables
17. Light table
18. Wall tool cab.
19. Bench unit
20. Matl. samples
21. Matl. tester
22. Injection mach.
23. Vacuum former
24. Thermoformer
25. Powdered metals
26. Metal shaper
27. N/C mach.
28. Offset
29. Roller/shear
30. Bender
31. EDM
32. Jointer
33. Surfacer
34. Wood lathe
35. Tool cab.
36. Box/pan brake
37. Lathe/miller
38. Vert./horl. bandsaw
39. Radial saw
40. Table saw
41. Grinders
42. Wood Welder
43. Arc/gas welder bench
44. Arc welder
45. Crucible furnace
46. Foundry unit
47. Bench furnace
48. Bench oven
49. Drill press w/ automatic feed
50. Bandsaw
51. Comb. belt/disc sander
52. Printer and developer
53. Drill press
54. Finishing bench
55. Bench w/stake plate
56. - 59. Benches

FIGURE 8

Equipment layout

The industrial education teacher serves as an advisor to the architect during this stage so design changes in the rooms will not harm the educational objectives and intended activities of the program.

Completion of detailed layouts.

Completion of detailed layouts should begin shortly after final approval has been received on the preliminary plans and expenditures have been allocated for construction. Complete sets of blueprints will be drawn by the architect, including elevations, overall and detailed room layout, structural details, mechanical details and specifications. At this time construction bids may be solicited to avoid further delays.

The architect must work within the framework of a budget which may be rigid. Compromises may have to be made in the requested specifications, such as different bus ducts, location of a power outlet, or other utilities. Some may affect program activities thereby reducing the effectiveness of the total program concept. If compromises affect space allocations, the effect on the educational program must be evaluated before making a final decision. Space is very critical to any educational program and should only be reduced as a last resort.

Construction.

During the construction stage the facility planning committee should maintain contact with the architect and contractor on the progress of the building or remodeling. There may be times during construction when the electrical, plumbing, or other contractors may have questions or need clarification on the positioning of certain items and will need to contact the teacher.

Watching the progress of the construction stage will indicate to the committee when the requisitioning and delivery of equipment should be completed.

Acquisition of equipment and materials.

This stage of the planning process may begin immediately following approval of expenditures. This should be the responsibility of the industrial education teachers who will be working in each of the laboratories. If the equipment list formulated for the educational specifications was well done, this step should be relatively easy.

Requisitions for equipment should include quantity, recommended suppliers, catalog numbers, machine and tool specifications, accessories, brand names, and vendor price. If bids are to be requested from several suppliers, the specifications must be accurately comparable. It cannot be assumed that certain accessories will be standard equipment from all suppliers. They must be listed in the requisition. Lead time is critical in ordering equipment. Requisitions should be completed well ahead of the deadlines for when they will be needed. Requisitions should be submitted to the school administration so purchase orders may be mailed out in time for delivery, installation, and testing of all equipment before student utilization. Communication should be maintained with the vendors to determine the status of the orders and to notify vendors of changes in delivery dates if final construction plans are delayed.

It may be a good practice to place a priority ranking on your equipment list for each laboratory. This becomes quite critical if equipment and material budgets are reduced due to errors in estimating equipment costs.

The committee responsible for equipment should know approximately what the equipment budget will be before completing the equipment requisitions. Much time may be lost by revising the list several times for reduction purposes. As price quotes are received from vendors, the committee should be notified immediately so further additions or deletions can occur if bids are lower or higher than originally expected.

Installation of equipment.

This part of the process takes considerable organization on the part of the industrial education committee in order to be ready to receive and position all equipment upon delivery. Again, lead time is critical if the equipment is to be inventoried, installed, and checked out before the school year begins.

One industrial education teacher should be responsible for checking all equipment orders as they are received so they can be cross-referenced with the purchase orders. After equipment deliveries have been checked, a receiving report should be sent to the school business manager. The items can be inventoried and the boxes marked as to which laboratory area they are to be moved into for installation or storage. Placing each item on inventory cards saves time later because all the necessary information is available. (See Figure 9 for a recommended inventory card to use during this stage.) The recommended information can be placed on a 4 x 6 index card for easy reference and filing.

Using the equipment layout generated in the educational specifications will provide for easier placement of larger pieces of equipment as they arrive in the laboratory. All equipment needing utility connections should be placed in position immediately to enable maintenance personnel and/or contractors to make proper hook-ups. Once utilities are connected, the teacher should thoroughly check out the operation of the equipment and note any discrepancies so they can be reported to suppliers for adjustment.

Some suppliers of equipment provide installation service. The industrial education teacher should be aware of this service, if provided, and contact the supplier when equipment is needed for installation. It is also important that any guaranty or warranty cards received with the equipment be filled out and returned to the supplier or manufacturer as soon as possible. For easy reference the customer copy of the guaranty or warranty should be filed with the inventory card.

Evaluations and modifications.

Planning, evaluating, and re-organization should take place continually if an industrial education laboratory is to be an up-to-date environment for learning to take place. This usually takes place during the first year the laboratory is in use. The industrial education teacher in each laboratory must play a key role in detecting any defects in equipment or building to assure proper commitments have been met between the school system and contractor or suppliers. Discrepancies should be noted and reported so that alterations may be made before guaranties and warranties expire.

Many times minor changes may be found desirable after a laboratory becomes operable. These modifications should be noted and changes made, if practical, so as to provide a better learning environment.

EQUIPMENT INVENTORY CARD

Name of Equipment: _____

Description: _____

_____

Serial No.: _____ Location: _____

Inventory					
Date	By	Date	By	Date	By

Purchase Order No.: _____ P.O. Date: _____

Purchase Rec'd. Date: _____ Cost: _____

Supplier: _____

Maintenance	
Date	Description

Figure 9

Recommended inventory card. Print on front and back side of a 4 x 6 card.

CHAPTER V
ENVIRONMENT AND SERVICE SPECIFICATIONS

The content found in this chapter is most applicable in writing the educational specifications for industrial education laboratories. Many teachers are not trained in writing environmental systems specifications. As a result, many important aspects are forgotten and not communicated to the architect. To consider an environment, thought must be given to the visual, auditory, air, and utility systems to be placed in the laboratory. An awareness of the balance of these systems is necessary by those responsible for planning the facility. Many times these decisions are left to the architect but the industrial education teacher should have some knowledge of which systems might best meet the demands of an industrial education program.

The laboratory environment in which an industrial education student works can have a significant effect on his emotional well-being, attitude, health, quantity and quality of work performed, and retention of learning. To establish a good environment is costly but the loss because of a poor environment is greater. Industry has learned that a favorable working environment does affect a worker's work habits and attitude toward work. We have the technology and engineering skills to provide an environment for learning, but too many times it is not used in industrial education laboratories because it is considered luxurious and eliminated from the construction because of costs.

Visual environment.

The environment of the industrial education laboratory can be improved significantly by proper application of color and good lighting techniques.

Color. First, let us consider color. Used properly, it can add interest to the student's surroundings and increase his satisfactions. Color can control the reflection of light, reduce fatigue, improve laboratory appearance, and promote safety.

Color has as its basis light waves. Composition and texture of materials cause differences in reflection and absorption of the light waves. For this reason it is important that correct materials and colors be selected for use in the industrial education laboratory. Visibility and light reflection are the greatest assets when selecting colors. The wrong color or surface may cause unwanted glare or reflection which may interfere with the safe operation of a machine or undue stress on the eyes. Warm colors, such as red, orange, and yellow are more visible, and are used to attract attention to areas of danger. Cool colors, such as blue, green, and violet are absorbed by most surfaces and thus do not reflect as readily. Greatest visibility is provided by black images on a yellow background such as found in floor safety zones or on walls outlining emergency equipment.

Color systems should be selected so there is a balance of reflected light to reduce excessive contrasts. Eye strain develops when the eye repeatedly moves from a high reflection area to a low reflection area. This strain tends to communicate a feeling of fatigue to other parts of the body. (4, p 5) An awareness of the reflectance values of various colors is important. (Figure 10 illustrates these reflective values in percentages.)

When white light strikes certain colors it is found that some color rays are absorbed rather than reflected resulting in a reflection of certain colors near the same basic color within the color spectrum. (Figure 11 illustrates this basic color reflection.)

It is recommended that industrial education laboratories have a minimum light reflectance of 20 per cent and a maximum of 90 per cent to be appropriate for the activities performed. Surfaces in the laboratory should have different reflective values so that a visual balance of reflected light is maintained throughtout the room. The following are some suggested reflective values: walls and partitions—50-65%; chalkboards—15-20%; lower wall section—50%; upper two-thirds of wall—60-65%; floor—30%; equipment—40%; and ceiling—75-85%. (5, pp 113-115)

Planning a color scheme for an industrial education laboratory is important and the colors selected should provide a good learning environment as well as an aesthetic appearance. Too much color may be distracting just as too little color provides drabness. It is recommended that no more than six colors, not including color code systems, be selected to prevent an unattractive laboratory appearance. (5, p 112)

Another important aspect of color in the laboratory is the color code systems to emphasize certain features for safety or identification. Two such systems are the Pittsburgh Color Dynamics and DuPont Color Conditioning. Both systems use color to achieve a visual separation of critical parts of equipment from non-critical parts. With these systems the

White	89	Pale Green	58
Ivory	83	Shell Pink	55
Canary Yellow	77	Bright Sage Green	53
Cream	76	Olive Tan	43
Orchid	67	Forest Green	22
Cream Gray	66	Coconut Brown	15
Ivory Tan	64	Black	1
Buff	63		

FIGURE 10

Reflective values of paints (51,p 176)

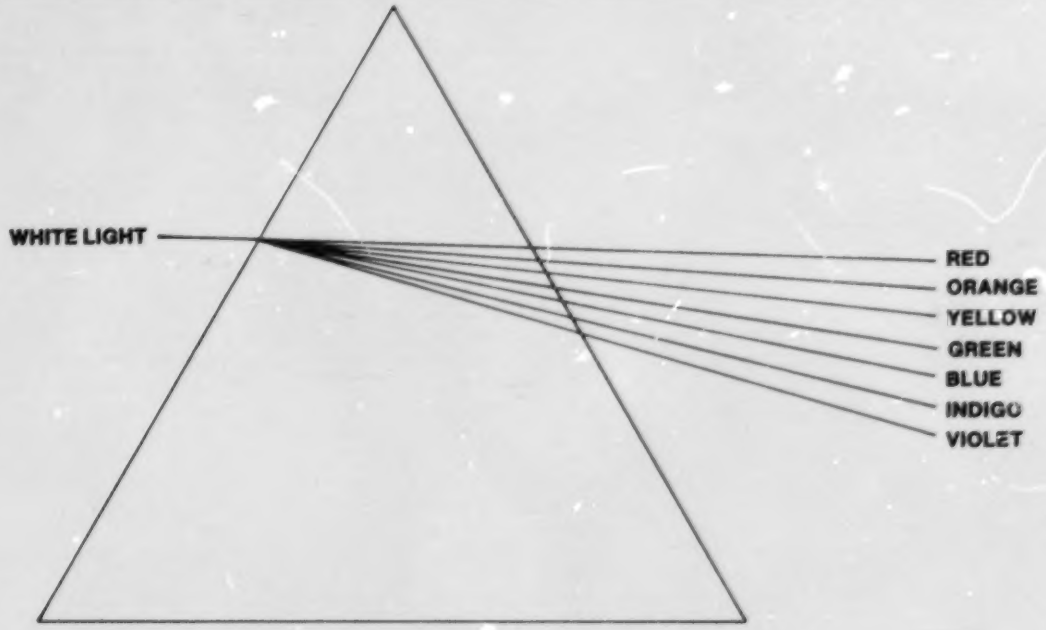


FIGURE 11

White light falling on a blue surface will absorb the yellow and orange rays almost completely, reflecting only blue, indigo, and the green which is near the blue in the spectrum. By painting a surface with mixed blue and yellow pigments a green is obtained because the surface will reflect only the color which is reflected by both blue and yellow pigments, which is green. (51,p 173).

operator's attention is focused on points of importance but they are not excessive in color reflection so that eye strain occurs. (Appendix II outlines both the Pittsburgh and DuPont color systems.)

Lighting. Although closely related to color because of light reflection and absorption, lighting is usually considered separately. Lighting is mainly concerned with the quantities and qualities of light from natural and artificial sources.

Most activities carried out in an industrial education laboratory are visual in nature and thus place demands on the student's eyes. The demands placed on a student's eyes vary from reading a micrometer or producing a working drawing to performing precision work on a machine. Poor lighting affects the quality, thus lighting assumes a key planning role in designing facilities.

The intensity of natural lighting outdoors on a sunny day ranges from 400 to 1,200 footcandles. This gives ideal lighting conditions for the majority of visual tasks. Unfortunately, costs and availability of equipment combined make it impractical to obtain desirable lighting in the range of 400 to 1,200 footcandles.

The efficiency of lighting systems has increased greatly from incandescent to fluorescent lamp systems. Along with this improved efficiency, costs of maintaining systems are lower.

Although natural lighting is desirable, it is rarely dependable. It must always be supplemented by artificial lighting of some type. This has brought about a growing tendency to eliminate windows in many buildings because windows are expensive and the expense of artificial lighting is still necessary with or without windows. Shadows and glare from sunlight are eliminated when windows are not included in a structure. Some single-story buildings are making very good use of sky-domes or clerestory lighting to take advantage of natural lighting while still maintaining maximum wall space. With the use of this type of natural lighting it is necessary to have tinted glass to prevent glare and excessive heat from the sun. Also there may be a problem in the use of visual projections for instructional purposes.

If windows are planned in the structure they should be at least six feet above the floor to give a proper light angle in the laboratory and still maintain good wall space. The use of tinted glass or a solar screen is recommended to decrease glare potential in the laboratory.

Of the two types of artificial lighting, the advantages of fluorescent far outweigh those of incandescent. The fluorescent lamp is capable of delivering three to four times more light per watt than an incandescent. It has a longer life, low heat output and low operating cost. By placing the fluorescent lamps in continuous banks close together and gaining good ceiling reflection to all parts of the room, it prevents shadows and unnecessary brightness at work levels. For best results light banks should be positioned one to two feet out from the wall to take advantage of good wall reflection. (5, p 129) To get uniform lighting over an area, the spacing of the lighting units should not be greater than the mounting height. (51, p 170)

Many times overhead lighting is not enough for doing precision work on a bench or at a machine. It is recommended that local incandescent lighting be used

where a point source of light is necessary.

The height of light banks is also important to provide uniform brightness and proper reflection to reduce glare and shadows. They must be high enough so they do not interfere with operations yet provide necessary lighting. For a ceiling height of fourteen feet and room width of more than thirty-five feet it is recommended that light banks be positioned twelve feet above the floor. (5, p 128) This height provides good aesthetics and a balance of reflectance from the ceiling. For every one foot of ceiling height increase, the lights should be raised six inches. For example, a 15′ ceiling should have lights positioned at 12′6″, a 16′ ceiling at 13′, and a 17′ ceiling at 13′6″. (6, p 4)

Specifying the correct type of color phosphors on the fluorescent tube will give greater efficiency in lighting. Cool white or deluxe white should be selected over blue or pink phosphor.

Lighting techniques, such as direct lighting, semi-direct, general diffuse, semi-indirect, and indirect, should also be specified for good quality lighting. Direct lighting gives the highest level of illumination but has harsh shadows and harmful glare because 90-100 percent of the light output is downward. Semi-direct has a 60-90 percent light output downward and is suggested for offices or other areas to relieve the contrast of an unlighted ceiling. General diffused lighting has a 40-60 percent light output downward and upward. Semi-indirect lighting provides a light output of 60-90 percent upward thereby practically eliminating glare and shadows at work levels. Indirect lighting removes glare and shadows by distributing 90-100 percent of the light upward. (52, p 18) This provides the best type of lighting for industrial education laboratories because it reflects light to all parts of a room from the ceiling and upper wall surfaces. (Appendix III illustrates a rough estimate of the various types of lighting in footcandles for each watt per square foot.) By following certain formulas, the number of lighting fixtures needed for a given area can be estimated.

Every auxiliary room should have its own light circuit. The main room should have separate controls for every two banks of fluorescent lights so that in the case of a circuit failure the entire room is not darkened and unused areas need not be lighted.

The minimum level of illumination required for an industrial education laboratory is higher than that in many other teaching facilities. (Appendix IV shows recommended minimum levels of general illumination for industrial education areas.)

Auditory environment.

General noise levels have steadily increased over the years due to increase in technology. Many noises may provide irritation which in time may impair hearing. The noise levels encountered in certain industrial education laboratories can become quite high, and at times, border on the danger zone. In these areas, adequate noise reduction treatment and prevention measures are mandatory so that the hearing of students and teachers will not be impaired.

Undoubtedly, lack of knowledge in controlling sound and its effect has contributed to this problem. Also some school districts have been unwilling, due to budgets, to spend the necessary money to have a good auditory environment. Carpeting and acoustical tiles are often used throughout the school to reduce noises. In industrial education shops where high noise levels are generated, very little is being done to reduce or prevent noises.

There are two separate aspects of providing a good auditory environment. The first is to control the noise within the space so the human voice may be distinguished intelligently. Second is to control unwanted sounds from outside the room, which is generally a more difficult problem.

Sound is a wave motion which travels generally through the medium of air but also travels through gases, liquids, and solids. It is very difficult to control because wherever air can flow, sound can be transmitted. It travels through solids by the vibrations being transferred from one layer to another, although some of the sound will be absorbed in the process.

The intensity or loudness of sound is measured in decibels. A decibel is a unit that is approximately equal to the smallest difference in intensity detectable by the normal human ear. Natural voice has an intensity of sixty decibels and a jet engine, one-hundred feet away, has an intensity of 130 decibels. Continued exposure to sound intensity greater than eighty-five decibels may cause damage to hearing. Sound intensities greater than 130 decibels have been known to cause immediate damage. (7, p 44) Conditions above eighty-five decibels are easily reached in an industrial education shop. For example, a surfacer has an intensity of 110 decibels, router—110 decibels, engine lathe —80 decibels, and a table saw — 110 decibels. These decibel readings will vary according to distance away and direction from the machine as well as how well maintained and sharp the blades are on the machine.

Theoretically, acoustical designs are created but a poorly maintained machine can nullify the acoustical design, so operational analysis is important.

Reduction of noise may be attained by the following: (1) control of noise at the source, (2) isolation of the noise, (3) baffles or sound absorbers, (4) acoustical treatment, and (5) using ear protectors. (7, p 44)

Location of the laboratory in the building should be where outside noises from playgrounds and busy streets do not have to be contended with in the building. Doorways leading into laboratories should be kept closed and not lead into open corridors where sound would have a tunneling affect to other parts of the building. Single-story construction is better so noise transmission to other floors may be reduced. Larger facilities with high ceilings tend to minimize noise concentration. Long, narrow rooms, which cause tunneling and echoes to result, should be avoided. Low ceilings will reflect sound waves. Ceilings of fourteen feet or higher will reduce this effect. In a classroom situation the lower ceiling provides better acoustics. Only full height partitions should be used because partial walls permit sounds to tunnel overhead thus echoing throughout connecting areas.

Exhaust systems should be well designed and installed so they aren't a source of steady sound. Although it may not be overly harmful, it is irritating over a long period of time. Reduction of the whistling of air flow to a minimum with good tight hose connections and a minimum of bends will aid acoustics. Using flexible hose for dust exhaust instead of sheet metal pipe will reduce the noise factor considerably. (See Appendix V for an example of one such system.) Storage hoppers for dust should be outside the building and away from any windows. The exhaust fan motors for these systems make considerable noise and should be isolated.

The use of sound absorbent blocks mounted on walls and ceilings aids in reduction of noise levels. The blocks should be mounted on the upper one-third of the wall space for best results. Also eliminating, where possible, glossy painted or textured surfaces which reflect sound waves, is recommended.

Selection, placement, and proper maintenance of equipment in the industrial education laboratory can do a great deal to reduce unnecessary noise. Equipment designed with good lubrication systems and enclosed motors and other moving parts, along with good sound construction, can remedy many noise problems. Install rubber grommets on vise handles so when they fall the sound is deadened. A solid cast iron stand or base reduces

sound more than a sheet metal base. Blanketing the inside of machine cabinets with insulation also reduces noise. Select machines with slow-speed motors where practical and not necessary to have high revolutions per minute to operate equipment. Brakes on machines such as bandsaws, radial saws, and jointers which take a long time to slow down after they are turned off, will reduce noise.

Where noise is a problem, equipment should be spaced around the laboratory rather than being concentrated. Placement of vibration and noise absorbent pads under the machines aids in reducing sound levels. Some of these vibration pads are combined mounts which insulate and level the machine to an eighty-five percent effectiveness. (8, p 3) The use of other materials such as Fabcel and Vibramat, are also effective in noise control as machine mounts.

Proper operating procedures should be followed to reduce noise. Excessively heavy cuts and fast feeds should be avoided. Circular saw blade set at the correct height creates less noise than one set too high; use proper blades to make cuts; and use the exhaust system only when required.

Maintenance of equipment can prevent unnecessary noise. Sharp cutting edges, replacing worn parts, lubrication, proper alignment, and mufflers on noisy parts all aid in reducing uncomfortable noise levels.

Air environment

Consideration must be given to the air environment. Air environment is concerned with the cooling, heating, and ventilation of the air within the building. It is not only important to the human being but also to equipment and supplies. Rust and corrosion of equipment, moisture content of lumber, wood finishing, and drying out of supplies such as paper, film, etc. are all affected by the air environment.

The primary objective of an air control system is to provide an environment that is free of impurities, odorless, temperature controlled, and has suitable moisture content. This can be done by properly blending with outside air, filtering, heating or cooling, humidifying or dehumidifying, and keeping the air gently in motion.

An industrial education laboratory requires good ventilation because of dust, heat, fumes, and gaseous waste materials generated during various processing procedures.

Ventilation is the movement of air throughout a space by pulling air in from the outside by fans and filtering it, then circulating it through a duct system. Some systems are central units which are designed to handle the entire building. Others are zone units for use in smaller areas.

Air movement is essential to restore oxygen and dilute carbon dioxide within the space. Wisconsin code requires five cubic feet per minute per pupil of outside air to be circulated. (53) For example, a room 3000 square feet with a fourteen foot ceiling which has twenty-four students present needing five cubic feet per minute per student must circulate the air about six times during a sixty minute period.

Heating controls should be located in the industrial education laboratories so they may be regulated according to activities. Due to the activity and heat produced by running machines the temperature in a laboratory can be adjusted much lower than in classrooms to conserve on energy.

Exhaust systems and ventilation systems must be coordinated with heating systems so heat is not drawn out of the laboratory causing an inbalance in the air environment system.

Exhaust systems are essential in all industrial education laboratories in order to minimize air contamination. The problem is critical enough to the health and safety of individuals that it should be required in all schools. In addition, sawdust on floors causes slipping accidents, dust causes more maintenance on machines, and fumes can cause fires or explosive conditions.

There are two types of exhaust systems to be considered for industrial education laboratories. These are solid matter (sawdust) and fumes (gas, finishing, chemical) systems. These systems must be totally separate to prevent combustion. Fans used must be spark free and operate at low temperatures to prevent ignition of materials.

Gaseous waste fumes can be exhausted into the atmosphere if properly filtered, but local codes should be checked to establish the correct filtering process. This would be necessary for diazo and other similar reproduction equipment or processes.

Finishing rooms should be equipped with a hood and fan connected to a duct to carry the fumes into the atmosphere. The hood should have a filter pad which should be changed regularly to permit clean filtering.

The hot metals area should be equipped with a hood and fan to carry away unwanted odors and fumes from melting metals. In a foundry area, be sure the hood is large enough to cover the furnace and pouring area, and high enough so it does not interfere with operations. In this same area it will be necessary to have either a hood or exhaust ducts over welding booths to remove welding fumes. These systems should be designed to pull fumes away from the operator and not up past his face. Building codes should be checked to determine the number of cubic feet of air per minute necessary to properly remove fumes.

The photographic darkroom is another area where it will be necessary to have an exhaust system to remove chemical fumes from developing processes. A simple ventilation duct with a fan installed in the ceiling over the developing area will sufficiently exhaust chemical fumes. The size of the fume duct and fan will vary according to the size of the darkroom. Once again, building codes should be checked.

Fume ducts for the hot metals area, finishing room, and darkroom may be ducted straight upward to the roof to provide an economical path as well as being less complex mechanically. These systems may be ducted through side walls but care must be taken that the ducted fumes will not be pulled back into the building through an open window or ventilation system.

Dust collection systems can be installed either overhead or under the floor. Under the floor systems provide less noise, minimize visable duct-work, and do not interfere with machine operations but they do restrict machine placement so flexibility is reduced. Under the floor systems are more difficult to install and maintain, especially when blockages occur. Adding new machines results in costly installation to permit connecting into the existing collection system. Duct work coming out of the floor can become a hazard to safety unless clearly marked. The best under the floor system utilizes an industrial trench idea, which houses all necessary utilities. A utility post is used which can be removed and stored when not in use and the trench opening is covered with a steel plate. (9, p 17) (An example of this utility post system is shown in Appendix VI.)

Overhead systems provide greater flexibility for movement of machines especially if attached to machines by flexible exhaust hose. If enough dust outlets are provided along the duct work, new machines can easily be attached by the teacher without any major expense. Reducing the noise factor of an overhead system can be done by putting vacuum sealed caps on each unused outlet. (See Appendix V for an example of this type exhaust cap.) The biggest disadvantage to the overhead system is the exposed ductwork which may be unsightly and interfere with light reflection from the ceiling.

Gradual tapering of ducts is recommended to provide

greater efficiency. (See Appendix VII for a duct system designed for a laboratory fifty feet wide and fifty feet in length.) Designing with a minimum of right curves will lessen the chance of blockages occurring. One or two floor ducts, depending on room size, are necessary to handle floor sweepings.

Dust storage hoppers should be located outside the building where noise will not interfere with classes and where they can be easily cleaned. The size of these hoppers is critical so they will not fill too quickly and cause sawdust to be blown into the atmosphere. It is recommended that a collector with a minimum capacity of fifty cubic feet be installed for efficiency and safety.

The efficiency of a dust collection system is dependent on its ability to move air at a high enough velocity to exhaust dust from all sources. Each machine requiring dust exhaust is rated as to how much velocity it takes to remove dust efficiently. (See Appendix VIII for the ratings of the common machines needing dust collection.) By totalling the velocity needed for each machine, and adding a safety factor of about twenty-five percent it is possible to obtain the total velocity required for a dust collection system.

Portable dust collectors are recommended for laboratories to supplement the main system because there are certain pieces of equipment which are difficult to completely clean with the main exhaust system.

Some characteristics of an effective dust collection system are listed below.

1. Exhaust hoods are designed to utilize the natural trajectories of waste materials.
2. Each exhaust hood is placed close to the source of dust production. Efficiency diminishes rapidly as distance increases.
3. No exhaust hood or duct is constructed or placed so that it interferes with machine operation, set-up, or maintenance.
4. Overhead ducts, except floor sweeps, are twelve inches or more away from walls, partitions, and ceilings, and six or more inches away from floors.
5. Branch ducts enter the main duct only on the top or sides, and do not connect directly opposite each other.
6. Branch ducts enter the main duct and other branch ducts at angles of forty-five degrees or less. Thirty degrees is recommended.
7. Round ducts are used throughout. If lack of clearance makes it necessary to use a rectangular duct, it should be as nearly square as possible and equal in area to the appropriate round duct.

Utility systems.

Utility systems for an industrial education shop should be considered an integral part of the design and not as appendages to be attached to a completed design and modified as the needs of the program become known. It is always best to provide the utilities in the original design even if they are not used immediately, rather than attempt modifications at a later date.

Industrial education programs primarily make use of four utility systems, (1) electrical, (2) water, (3) gas, and (4) compressed air. Electrical and water are a necessity in all laboratories. Gas is essential if a hot metals area with a crucible furnace and heat-treating equipment is planned. Compressed air will be needed for spray finishing, injection molding, blow molding, pnumatic tools and fluidics.

Extra capacity should be considered so that new equipment, greater capacity equipment replacing older equipment, and new processing techniques may be added without necessitating major changes or additional cost. Undercapacity may be a problem not only when alterations are made, but may cause unsafe conditions for students working in the laboratory.

It is best to plan for the use of standard utility service accessories rather than special fittings, outlets, or valves. It is not always a good practice to go with the least expensive items unless safety and durability have been carefully considered and the less expensive item still showed to be the best buy. Replacement frequently may be more expensive than using more costly original equipment.

Electrical. Although the engineer installing the electrical system will be aware of national, state, and local codes, it is essential that the industrial education teacher be able to provide information regarding machine specifications for present and future equipment. The teacher can organize a machine specification matrix showing all equipment requiring electrical power according to voltage, amperage, phase, and horsepower. Also, having a machine layout available for the electrical contractor will allow for determination of loading capacity on circuits throughout the laboratory. Machines, convenience outlets, welders, exhaust and fume systems, and lights should be on separate circuits. Machines should also be protected by installing magnetic switches in case circuits fail. Magnetic switches are usually required by code as a safety precaution.

Each laboratory should have a main switch panel equipped with circuit breakers for each circuit and a master switch to control all circuits. It is also recommended that panic buttons be located around the laboratory so power may be switched off in the case of an emergency.

It is practical to plan for 120/208 volts with single and three phase service being made available in the laboratory. Higher voltages should be kept at a minimum unless absolutely necessary because of high cost installation.

A decision must be made on whether an overhead or under the floor busduct system should be installed. One of the major considerations is flexibility. The overhead busduct provides the greatest amount of flexibility because the power plug-in modules can be easily attached or removed so machines can be relocated and new machines installed. Most contractors believe the installation cost is less for an overhead system because raised floor networks and placement of access doors in the floor for making machine connections cause additional expense. (Appendix VI illustrates one under the floor system which might be considered.) The overhead system can cause aesthetic design, light and noise reflection problems due to many hanging electrical cables. Also, many instructors may not like the power cables from above which may interfere with certain machine operations. (Appendix IX shows two types of overhead electrical systems.)

It is recommended that a wall-mounted electrical raceway be installed around the perimeter of the laboratory with 120 volt, single-phase capacity. The amperage of the raceway should be determined by the number of items which will potentially be making use of the raceway at the same time. Usually twenty amps will be sufficient. The raceway should be located approximately 42 inches to 48 inches above the floor so it is easily accessible and not in the way of bench height activities. Duplex convenience outlets should be located along the raceway approximately ten feet apart.

It is recommended that several 120 volt, single-phase reel type dropcords be provided from the overhead busduct to eliminate the use of extension cords as much as possible.

Electrical energy for auxiliary rooms should also be carefully planned. Photographic darkrooms will need outlets for vertical or horizontal cameras, enlargers, printers, dryers, and possibly a refrigerator for storing film. Switches should also be planned for normal lighting, darkroom lights, fume exhaust, and a "room in use" light

outside the door. These switches may be positioned at different heights inside the door so accidentally turning on the wrong switch does not occur.

At least one outlet should be provided in each storage room for portable tools.

A finishing room convenience outlet should be installed with a cover plate to protect against finishing liquids splattering into them causing short circuits or fires.

Water. The industrial education laboratory needs water primarily for clean-up, drinking, and special processes, such as molding clay, coolant and photo developing. Usually 40 psi water pressure and standard one inch pipe is satisfactory for the laboratory.

It is recommended that a circular or half-circular type clean-up sink be installed with hot and cold water, and a cleansing soap attachment. The half-circular type saves floor space and can be mounted against the wall for easier plumbing installation.

Slop sinks with hot and cold water are recommended for removal of residual waste such as grease, finishes, inks, and oils. Special clean-out traps should be provided and the drain should be at least three inches in diameter for easy removal of waste materials.

In the power and energy areas it is suggested that arrangements be made for a floor drain to handle the washing down of engines and the floors to remove oily waste residuals.

Because of the potential of fire due to sawdust, grease, paints, and oil in the industrial education area, a ceiling sprinkler system is recommended. This is especially true in finishing rooms or large spray booths.

Chemical resistant photographic darkroom sinks should be installed. Usually, stainless steel or the newer fiberglass types are desirable. A water softener system may be considered if the water contains large amounts of minerals which might contaminate the darkroom chemicals or water being used as a coolant. If constant temperature is needed for darkroom use a temperature control unit may be installed on the darkroom sink.

Drinking fountains should be provided in laboratories. The refrigerator type drinking fountain is best for proper drinking water temperature.

Where water lines, sinks, and fountains are located, care should be taken to prevent water spillage which may cause slippery floors or electrical accidents.

Gas. Natural gas is the best and provides the safest control. The number of gas outlets will be determined by how extensive the hot metals area is to be. Each gas line should have its own shut-off valve located near the piece of equipment. Each gas line and valve should be properly marked.

In order to provide correct piping specifications it is necessary to state the BTU per hour requirements of each piece of equipment needing gas. By adding up equipment requirements, the total capacity of gas needed at any one time may be determined. For example, a two-burner bench soldering furnace requires 26,000 BTU/hr. and a #900 crucible furnace requires 130,000 BTU/hr. If both pieces of equipment were running at the same time 156,000 BTU/hr. capacity service would be required.

Crucible furnaces should be equipped with automatic safety controls which will automatically close the gas valve in cases of electrical, gas, or air failure.

Compressed air. The industrial education laboratory should be equipped with compressed air outlets because of expanded use of air in many processing operations, such as spraying, flocking, injection molding, blow molding, air tools, and air operated cylinders. Air should never be used for clean-up purposes in the laboratory, unless the pressure can be reduced to below 30 psi for safety. Hand air bellows or portable vacuum collectors are best for cleaning machines.

In making specifications for air systems it is necessary to note the pounds per square inch (psi) and cubic feet of air movement per minute (cfm). Usually 125 psi maximum and a total volume of 150 cfm is satisfactory for most industrial education laboratories. Air utilization is most generally intermittent, therefore unusually high pressures and large air volume is not required.

The selection of the air compressor is critical. It should be selected on the basis of psi, cfm, quality, and manufacturer. A start-stop compressor control is best for intermittent service conditions. This type can be set to start and stop at the desired pressure build-up in the tank. If at all possible, the compressor should be located outside the laboratory to minimize excessive noise.

Air lines should be mounted on the perimeter wall about 45 inches off the floor. If the laboratory is more than 30 feet wide, it is recommended that an overhead air line be provided in the center of the laboratory. Air outlets should be positioned every 15 feet along the line. Flexible hose coils should be connected to the overhead air line so they are not hanging down too low. For control purposes, each laboratory should be equipped with a main shut-off and gauge. Air gauges should be available at every connection point to meet safety regulations.

There are systems available which are continuous air lines and do not need air outlets along the line. Special air hose probes are plugged in anywhere along the air line at intervals of approximately one inch. Different numbers of probes mounted on the air hose will determine the amount of air to be obtained from the main line. (See Appendix K for an illustration of the continuous air system.)

Communication utilities

With the potential of television equipment being used in industrial education it is recommended that the laboratory be equipped with a television monitor outlet. The use of television for giving demonstrations to large groups and video recording for independent study can be very beneficial.

It is recommended that a telephone be available for easier contact with outside resources, suppliers, and making arrangements for field trips to industry.

If electronic communications is to be a part of the curriculum, plans should be made to have an antenna mounted on the roof of the building with several access connections in the communication area of the laboratory.

CHAPTER VI
EQUIPMENT RECOMMENDATIONS

Selection criteria.

Equipment recommendations for industrial education facilities must be prepared early in the planning stage. Space requirements must be known for each piece of equipment in order to plan for proper amounts of total space. Utility requirements will have to be known by mechanical and electrical engineers early in the planning process. Equipment lists prepared for educational specifications will only include kinds of equipment and utility needs so construction specifications can be completed. A more complete list of equipment and supplies must be prepared eight months to a year prior to installation of the equipment.

Wise acquisition of equipment helps to ensure a smooth operating program, one free of disrupting breakdowns. The only real basis for selecting equipment is the educational program to be offered within the facility. The teacher should be instrumental in selecting equipment for the laboratory. Activities determine the choices of equipment. It is critical that the selection committee be aware of the curriculum and the activities which will be experienced.

One major weakness in the selection and purchase of equipment for industrial education facilities is the lack of specific and complete information about the item being requested. This slows the purchasing process, resulting in late deliveries or wrong pieces of equipment being received. Following is an example of how equipment should be requisitioned.

1—#33-793 (brand name) 12″ Radial Saw. Mounted on bench with #50-104 set of legs. Equipped with a safety return and complete blade cover guard. One 12" crosscut blade included. Motor: 2 hp. 208v, 3-phase with magnetic switch and starter. Switch should be a key lock type. Brake included.

1—#TS1 Tool Storage Cabinet, wood. Size: 48″ wide x 22″ deep x 84″ high. Frame is hard maple and panels are birch plywood. Has two 59″ x 18″ birch ply tool panels which revolve 360 degrees permitting tool storage on all sides as well as on back and ends of cabinet. Equipped with four drawers each 21″ wide x 18″ deep x 6″ high. Doors and drawers fitted with master keyed locks. Natural finish.

In most cases, cost may not be the major selection criterion. High cost and high quality do not necessarily go together. Criteria such as safety, durability, design, function, operating characteristics, accuracy, versatility, and service should be carefully judged before a piece of equipment is recommended. Function, appearance and manufacturer's service seem to be the three greatest factors to be used in the selection of equipment.

A piece of equipment must be selected in terms of its potential for educational development of the student as well as a valid production function. When evaluating the function of a piece of equipment, consideration should be given to the age, size, strength, and coordination of the students who will be using the equipment.

The appearance of a piece of equipment should relate good design principles and fit into the design of the total facility. A product may lack good design resulting in poor balance and unsafe or difficult operational characteristics.

Selecting manufacturers who provide good service is essential to an efficiently operating industrial education facility. It is wise to be familiar with service warranties and guarantees offered by manufacturers. Availability of technical service at nearby service centers, parts availability for the expected life of the equipment, and operating manuals and parts lists are important. Installation service may be included in the price.

Requisitioning equipment can be difficult unless a step by step breakdown of necessary specifications is followed. It is suggested that the following items be included in specifications: (1) item model number, (2) quantity, (3) unit of measure, (4) manufacturer's or supplier's catalog number, (5) manufacturer's name, (6) name of item, (7) description as to size, color, voltage, amperage, phase, horsepower, etc., and (8) accessories and/or equipment which are to be included. These specifications become particularly important when bids are sent out to various manufacturers. One manufacturer may consider the blade, fence, miter gauge, or table extension as standard equipment on a table saw and his bid will be higher than a manufacturer who does not include these accessories. If the school district business manager accepts the lower bid, a machine without the necessary accessories to operate may be purchased. It is very important that the purchase requisition, purchase order, and bid notices be carefully reviewed to assure the correct piece of equipment needed for the facility will be ordered.

An inventory system is important in equipment ordering so records may be kept of purchase dates, suppliers or manufacturers, and maintenance schedules. This information is important when ordering parts or replacements for present equipment. Often, a teacher has no idea how old a machine is, thus it becomes questionable whether he should replace it. The maintenance record helps to account for cost each year on equipment. When maintenance is frequent, it may be time to purchase a new piece of equipment. (The inventory system suggested was explained in Chapter IV of this guide.)

Equipment recommendations.

The following equipment lists are suggestions only and are by no means to be considered complete. The number of items in each case will vary according to enrollment and program. The lists are broken down according to the curriculum programs suggested by the *Wisconsin Guide to Local Curriculum Improvement in Industrial Education.*

Elementary Grades K-3:

Bench, with combination vises.
C-clamps, 2″ & 4″.
Brace, 7″.
Hand drill, 1/4″ capacity.
Auger bits, 1/4″, 3/8″, & 1/2″.
Drills, carbon 1/16th to 1/4th by 16ths.
Hammer, claw 10 oz.
Mallet, rubber.
Rulers, 12″ wood or metal.
Square, try 6″ blade.
Pliers, combination 6″.
Saw, coping 6″.
Saw, crosscut 16″ w/10 points/inch.
Saw, hack 10″.
Screwdriver, 4″.
Scissors, 6″.
Snips, tin 8″.
File, flat wood 8″.
File, mill 8″.

Elementary Grades 4-6:

Benches, with 4 vises.
Brace, 8″.
Auger bits, 1/2″ to 1″ by 16ths.
Safety waste can.
C-clamps 4″ & 6″.
Countersink, brace 3/4″.
Drills, carbon 1/16th″ to 1/4″ by 16ths.
Drill, hand 1/4″ capacity.
File, flat wood 8″.
File, half round 8″.
File, round 8″.
File, square 8″.
File, mill 8″.
Hammer, ball peen 4 oz.
Hammer, claw 10 oz.
Mallet, wood or rubber.
Oil can, pint size.
Plane, block 6″.
Plane, smooth 9″.
Pliers, combination 6″.
Pliers, needlenose 6″.
Rule, bench 24″ wood or metal.
Elementary experience learning kits.
Saw, coping 6 1/2″.
Saw, compass 12″.
Saw, back 10″ w/14 points/inch.
Saw, crosscut 16″ w/10 points / inch.
Saw, rip 16″ w/6 points / inch.
Saw, jib 18″.
Screwdriver, 4″ & 6″.
Screwdriver, Phillips #1 to #4.
Square, try 6″.
Square, combination 12″.
Square, steel 7″x12″x1″.
Wrench, crescent 6″.
Wrench, combination 3/8″ to 1″.
Snips, tin 8″.
Saw, hack 10″.
Miter box saw, 24″x4″.
Drill, electric 1/4″ capacity.
Sander, finishing.
Buffing wheel, 6″.
Tool storage cabinet or bench.
Linoleum block tool set.
Silk screen kit.
Project storage cabinet or bench.

Junior High School

Materials & Processes Laboratory:

Benches, wood tops and bases 2′ x 4′, 2′ x 5′, 2′x 6′.
Benches, metal tops and bases 3′x 5′.
Benches, micarta tops and wood bases 2′ x 5′.
Bandsaw, metal and wood 14″.
Saw, table 10″.
Jointer, 8″.
Sander, belt & disc 10″ disc & 4″x48″ belt.
Grinder, bench or pedestal 6″.
Buffer, bench or pedestal 6″.
Surfacer, wood 5″ x 13″.
Hacksaw, power.
Drill press, 15″ floor model.
Lathe, wood 12″.
Lathe, metal 10″.
Milling machine, horizontal bench type.
Milling machine, vertical bench type.
Bender, 1/2″ capacity.
Box and pan brake, 24″.
Squaring shears, 24″.
Rollers, sheet metal 24″.
Drill press, 15″ bench model w/automatic air feed.
Injection molder, bench model.
Vacuum former.
Pop riveter set.
Leather tools.
Tap & die set.
Miter box saw, 4″x24″.
Spot welder.
Soldering furnace.
Propane gas torch.
Spray booth.
Finishing cabinet.
Tool storage cabinets.
Lumber racks.
Metal storage racks.
Supply storage cabinets.
Plastic strip heater.
Drill, electric 3/8″ capacity.
Sander, finishing.
Jigsaw, 24″.
Portable belt sander, 4″x24″.
Sabre saw, portable.
Gluing bench.
Gluing clamps.
Heat treating furnace.
Planning bench.
Drill press vises.
Vises, bench wood.
Vises, bench metal.
Quick acting toggle clamps.
Complete assortment of basic hand tools.

Communications Laboratory:

Drafting tables w/drafting machines.
Drafting instruments.
Triangles, T-squares, & curves
Templates, assorted variety.
Inking sets.
Scales, architectural & engineering.
Scales, metric.
White printer & developer, 36″ wide.
Silk screen sets.
Proof press, 15″ x 19 1/4″.
Pilot press, 6 1/2″x10″.
Type cabinets w/type.
Type setting accessories.
Paper cutter, 24″.
Offset press, 14″x18″.
Offset platemaker.
Typewriter, w/carbon ribbon.
Planning tables.

Benches, micarta tops & wood bases, 2'X4'.
Darkroom developing sink.
Enlarger, 8X10.
Printer, contact.
Film developing tanks.
Print dryer.
Developing trays, tongs, clamps, bottles.
Darkroom timer.
Layout & light tables.
Refrigerator for film storage.
Supply cabinets.
Bookbinding bench w/accessories & supplies.
Printmaker w/bench.
Electronic communication sets, including record player, hi-fi system, and public address system.

Power/Energy Laboratory:

Benches, wood tops & metal bases 2'X4', 2'X5'.
Benches, metal tops and bases 2'X5', 2'X 6'.
Bench vises, metal.
Supply storage cabinets.
Project storage cabinets.
Basic electricity trainers.
Multi-meters (volts, amps, & Ohms).
Tube tester.
Wind tunnel tester.
Fluid power trainers.
Hydraulic cylinders.
Pneumatic cylinders.
Drill press, 15" bench model.
Grinder, pedestal 6".
Lathe, metal bench model 10".
Arbor press, 5 ton.
Parts washer.
Spark plug tester.
Small engine dynamometer.
Air compressor, portable.
Spot welder.
Compression tester.
Cell tester.
Coil-condenser-ignition tester.
Waste oil container.
Cleaning fluid containers.
Engine stand for small engines.
Outboard motor rack.
Soldering furnace.
Heat treating furnace.
Drill, electric ⅛" capacity.
Two & four cycle engines.
Tool storage cabinets.
Mechanical transfer systems.
Two & four cycle engine models.
Aircraft engine models.
Steam engine model.
Small engine tachometer.
Solar cell units.
Wind mills.
Basic electrical hand tools.
Basic power/energy hand tools.

Senior High School

Materials & Processes Laboratory:

Lathe, wood 14".
Lathe, metal 12".
Horizontal milling machine, 6½"X24" table.
Vertical milling machine, 6½"X24" table.
Turret lathe, 1" capacity.
Shaper, metal 8".
Numerical control vertical mill, bench type.
Grinder, pedestal 6".
Grinder, surface 8"X12"X12".
Buffer, pedestal 8".
Power cutoff saw.
Bandsaw, combination wood/metal 20" w/welder.
Jointer, 8".
Uniplane, 8".
Saw, table 10".
Radial arm saw, 10".
Surfacer, wood 24".
Shaper, wood
Drill press, 15" floor model w/variable speed.
Drill press, 15" bench model w/automatic air feed.
Material tester, universal
Crucible furnace.
Heat treating furnace.
Soldering furnace.
Arc welder.
Oxy-acetylene welding outfit.
Welding booth.
Spot welder.
Bender, ½" capacity.
Box & pan brake, 24".
Bar folder, 24".
Squaring shears, 24".
Rollers, sheet metal 24".
Punch press, hand turret.
Notcher, 6X6.
Sheet metal bench.
Foundry bench w/accessories.
Vacuum former, 10X14.
Injection molder.
Compression molder.
Dip molding plastic oven.
Strip heater, 34".
Benches, wood tops & bases, 2'X4',2'X5',2'X6'.
Benches, metal top & bases, 3'X5'.
Multiton material handlers.
Lumber storage racks.
Metal storage racks.
Tool storage cabinets.
Finishing cabinet.
Supply storage cabinets.
Planning bench.
Drill, electric portable ⅛" capacity.
Router, portable.
Sabre saw, portable.
Sander, finishing.
Sander, portable belt.
Sander, combination belt/disc w/dust cabinet.
Portable 8" saw
Miter box saw, 26"X6".
Pop riveter set.
Tap & die set.
Drum sanders.
Spray booth.
Wood welder, 1½" capacity.
Plastic welding gun.
Sewing machine, heavy duty.
Small parts storage cabinets.
Anvil, 150 lb.
Quick acting toggle clamps.
Jig and fixture clamps.
Gluing clamps.
Leather tools.
Assorted basic wood tools.
Assorted basic metal tools.
Precision measurement tools.
Small conveyor, 12" X 10'.

Communications Laboratory:

Drafting tables w/drafting machines.
Drafting instruments.

Templates, and guides.
Lettering sets.
Inking sets.
Air brush w/accessories.
White printer & developer, 36″.
Blackboard or wall drafting machine.
Silk screen sets.
Vertical camera, 16 X 20 copy size.
Enlarger, 8X10.
Darkroom developing sink.
Developing accessories.
Contact printer.
Print dryer.
Refrigerator for film storage.
Darkroom timer, 60 second.
Offset press, 14 X 18.
Offset plate exposure unit.
Pilot press.
Proof press.
Bookbinding bench w/accessories.
Printmaker bench.
Type cabinets w/type
Type setting accessories.
Light tables.
Camera, 35mm w/flash unit.
Planning tables.
Supply cabinets.
Paper cutter, 36″.
Paper drill.
Collator unit.
Stapler, power.
Perforator.
Spiral binder & punch unit.
Typewriter w/carbon ribbon.
Electronic communications sets, including record player, hi-fi system, public address, radio receiver, radio transmitter, telegraphy, light beam, telemetry, and antenna transmissions.
Television.
Video tape recorder.
Picture phones.
Motion picture camera & projector.

Power/Energy Laboratory:

Electrical energy trainers.
Multi-meters.
Oscilloscopes, 5″.
Tube tester.
Variable DC/AC power supply.
Oscillators.
Industrial circuitry kits.
Computer circuitry kits.
Fluid power trainers.
Micro-wave units.
Laser beam unit, bench model.
Solar cell unit.
Mechanical transfer kits.
Wind tunnel tester.
Hydraulic cylinders.
Pneumatic cylinders.
Air vise.
Rotary table, air.
Linear table, air.
Dynamometers.
Compression tester.
Chain hoist.
Engine stands.
Coil-condenser-ignition tester.
Valve face & seat grinder.
Parts washer.
Spark plug tester.
Air compressor, portable.
Cell tester.
Outboard motor tank.
Arbor press, 5 ton.
Drill press, 15″ floor model.
Lathe, metal 10″.
Grinder, pedestal 6″.
Spot welder.
Oxy-acetylene welder.
Arc welder.
Welding booth.
Power demonstration models, assorted types.
Basic small engine tools.
Basic automobile engine tools.
Basic electrical hand tools.
Engine tachometer.
Spark plug cleaner.
Automobile hoist.
Small engine bench.
Benches, metal tops & bases, 3′ x 5′, 3′ x 6′.
Supply storage cabinets.
Flammable liquids storage cabinet.
Flammable liquid containers.
Oily rag and waste containers.

Construction Laboratory:

Benches, wood tops & bases, 2′ x 6′.
Wooden horses.
Saw, table 10″.
Saw, table 12″.
Saw, radial 12″.
Bandsaw, wood 20″.
Jigsaw, 24″.
Drill press, production 20″.
Lathe, wood 12″.
Shaper, wood.
Jointer, 8″.
Uniplane, 6″.
Sander, belt and disc.
Grinder, pedestal 6″.
Surfacer, wood 5″ x 18″.
Router, portable.
Saw, skil portable 8″.
Saw, sabre.
Drill, electric ½″.
Drill, electric ⅜″ variable speed & reversible.
Sander, finishing.
Sander, portable belt.
Finishing storage cabinet.
Lumber racks.
Supply storage cabinets.
Tool storage cabinets.
Fastener storage cabinet.
Gluing clamps, bar & C-clamps.
Gluing bench.
Site layout equipment.
House framing kits.
Plumbing fixture kits.
Welding station w/accessories.
Material tester.
Air conditioning trainer.
Heating trainer.
Masonry equipment.
House wiring sets.
Paint sprayer w/accessories.
Air compressor, portable.
Ladders, step.
Assorted construction hand tools.

Resource/Media Center:

Bookcases.
Display cabinets.
Planning tables.

Work tables.
Desks and chairs.
File cabinets.
Magazine racks.
File card storage.
Xerox machine.
Ditto machine.

Production Management Center:

Desk and chair.
File cabinets.
Magnetic production board.
Magnetic organizational board.
Time clock w/card rack.
Stop watches.
Plant layout models.
Dispatch board.

Audio-Visual Equipment:

16mm film projector, sound.
8mm single concept film projector.
Film strip projector.
Slide projector.
Tape recorder, reel.
Tape recorder, cassette.
TV camera w/tripod.
Video tape recorder w/slow motion.
Overhead projector.
Opaque projector.
Equipment storage cabinets, w/locks.
Film strip, slide, cassette, tape storage.
Wall mounted viewing screen.
Viewing screen, portable.
Mobile A-V tables.
TV monitor.
Rear-view projection unit.

CHAPTER VII
FINANCIAL ALTERNATIVES

Financial variables.

The overall objective in financing the construction of facilities is to get the largest amount of usable space possible per dollar spent. Therefore, all spaces should be carefully analyzed to determine the actual utilization by students and teachers when programs become operational. Rarely used, uneconomical, non-instructional areas should be minimized. Since the cost of facilities is important, careful planning is needed to receive the maximum amount of usable space. The cost of all phases of building construction should be estimated as carefully as possible before seeking funds.

Across the nation the school-age population is stabilizing or, in some districts, declining. (16, p 5) This may suggest a lack of school building needs, but this is not entirely true. Previous demands for new construction in growing areas forced many school districts to overlook maintenance and modernization of old buildings. These school districts now face the problem of replacement or renovation. Many schools built in the nineteen-fifties or before, did not anticipate the changes in education and are obsolete.

If school districts are to meet new demands, the ability to finance new buildings and/or modernization programs will be a critical factor. Some school districts find their capital outlay budgets very minimal. Others have used up their legal capacity to support long-term financing. Still other districts have found voters refusing to support new taxes to pay for new construction.

Construction costs are continually rising. Cost estimates based upon floor space requirements should take into account probable construction costs at the time construction will actually occur.

The U.S. Office of Education has listed several important variables to be considered in cost comparisons for school facilities. (45, pp 25-26) These variables are as follows:

1. Nature of the educational program to be housed.
2. Proportion of actual instructional space to total area of the building.
3. Number and kinds of educational equipment included in construction costs.
4. Labor wage rates and costs of construction materials.
5. Site preparation and development.
6. Availability of utilities.
7. Geographic location.
8. Design and type of building planned.
9. Construction methods utilized.
10. Building materials.
11. Cost trends.
12. Availability of labor for skills required.
13. Amount of off-site and on-site construction necessary.

The cost of all phases of building construction should be estimated as carefully as possible before seeking funds from outside sources. The U.S. Office of Education recommends the following items be considered: (45, p 26)

1. Land acquisitions.
2. Building contracts.
3. Architect fees.
4. Engineering services.
5. Consultant services.
6. Administrative expense.
7. Legal services.
8. Interest during construction.
9. Insurance during construction.
10. Site development.
11. Contingencies.
12. Clerk-of-the-works.
13. Furniture and equipment.

Sources of funds

The basic source of school funds up until 1945 was from local revenues. Since that time school construction needs increased markedly due to the need to accommodate the increased numbers of students, population shift to urban areas, the need for replacement of antiquated school buildings, the development of new educational programs, and school district reorganization. (27, p 165) Many school districts found it difficult, or even impossible, to fulfill the facility needs solely upon the local property tax income. State legislatures responded to this situation in a variety of ways, shifting the school construction financing burden partially to sources other than property taxes. No general programs of federal financial support for school construction have been developed. However, the Vocational Act of 1963 and the Amendment of 1968 do provide Federal construction funds for occupational programs.

In the State of Wisconsin, the burden of facility construction and remodeling of elementary and secondary schools lies largely with local school districts.

Alternatives may be available for financing school facilities but each state may vary on the legality of using certain methods. School districts should have a financial and legal consultant for this part of the planning project. These alternatives are suggested by the *Educational Facilities Laboratories.* (36)

Pay-as-you-go financing.

The pay-as-you-go process means the school district pays cash for all construction and equipment in the new facility. This method may be done through (1) one-time levies approved by the voters at a referendum, or (2) accumulation of money in reserve funds.

The one-time levies have been criticized because they burden the taxpayers at one point in time, while future taxpayers may pay nothing for school construction. Long-term financing is preferred over one-time levies because it spreads the burden more evenly among the taxpayers. However, long-term financing requires large amounts of

interest charges which may increase the cost of school construction beyond the limitations of the school district.

Accumulation of funds is similar to a manufacturing company accumulating funds for future expansion or new building projects. Some government planners and economists believe this would be a sound plan for many school districts. However, some states have made this practice illegal. This method does accumulate interest and avoids finance charges but may not always be economical due to rapidly and consistently increasing construction costs.

State aid.

State aid programs have grown in usage since World War II. These consist mainly of grants-in-aid and state loan programs. The State of Wisconsin does not offer a grant-in-aid program but does have a state loan program for those districts who can qualify.

The grants-in-aid are gifts from the state to the school district to supplement local funds for school construction. State loan programs are usually granted only to districts who are unable to support additional bonded indebtedness because they have reached their legal debt limit, cannot pass bond issues, or cannot market bonds.

Federal aid.

Presently, the only federal aid available for school construction is the Federal Impact Aid Program (Public Law 815) and vocational-technical schools.

The Impact Aid Program assists school districts where the presence of government installations have increased student enrollment by six percent over a four year period of time. (36, p 9) The Vocational Act of 1963 and the Amendments of 1968 do provide for funds to districts where there is a need for occupational education.

Reducing site costs.

Acquisition and preparation of property may be a large percentage of the total construction costs. Savings can be made in ways such as acquiring land that has been designated as urban renewal.

Because public land within a city produces no tax income, most cities do not want to give up taxable land for school construction. Some school districts are looking into the possibility of building schools over or under existing public land. For example, the Dade County School District, Miami, Florida, has proposed building an elementary school under a federally owned elevated expressway. The land will be leased to the school at a nominal sum. (36, p. 10) This may pose several problems such as, need for long spans, heavier construction, noise and vibration, and additional safety precautions but it still is an alternative which will reduce site costs.

Shared facilities

Many times community agencies are building facilities which could be shared. Rather than duplicate and build separate facilities, build one facility and share the space. Physical education facilities shared with the city recreation department or community library which serves the schools as well as the community may be possible. Perhaps industrial companies may need training facilities and would be willing to join with the school district in building a shared facility. The schools would use the shops in the day-time and industrial classes during the evening hours.

One of the major problems is finding other agencies that are willing to share facilities. One should check agencies at the city, county, state, and federal level to see what the possibilities might be for sharing a common facility. Potential groups related to industrial education might include vocational and adult education, local arts and crafts clubs, hobby clubs, junior or community colleges, technical education, and industrial training programs.

Once an agency is found which will share a common facility it will be necessary to establish a cost-sharing formula. One method might be to share total costs of construction and equipment on the basis of pro-rated usage. A second method would be for one agency to finance the construction and then lease or rent to the other agency. A third way would be for one agency to finance the cost of construction and simply give the other agency the right to use it. These methods would avoid the cost of duplicating facilities for community taxpayers.

Non-tax revenue

School districts many times own valuable land but are unable to finance the cost of construction for many years or the district may have purchased a good piece of land five or ten years in advance of building as a future investment against enrollment increases. This land may be rented or leased during the interim period to provide additional funds. This income to the school district over a period of years may be a feasible way to offset construction costs.

This particular method of financing may pose legal and political problems for the school district. If used, it should be only on the advice of legal counsel and after careful considerations of the local community.

Bond issues

Because of increased costs of constructing and equipping schools, long-term financing has become the traditional method used to gain sufficient funds for building. General Obligation Bonds are the media most often used for long-term financing. They can cover site acquisition, improvement costs, planning costs, construction of new facilities, additions to existing structures, and major renovations. Several projects may be built under one bond issue, but care must be taken not to group too much or too wide a variation of projects under one issue. Taxpayers may be for certain projects and not for others, thereby voting against the bond issue when grouping is used.

The school district must determine whether it can legally issue bonds in the amount required. This is controlled by debt limit. Limits are usually established by state law. The total indebtedness permissible for a school district will be based on a percentage of the equalized value of real estate owned in the school district.

Rural and suburban areas where property valuations are low have a disadvantage. Low debt limits create a problem in issuing bonds to obtain finances for construction purposes. Cities, where highly developed areas have a high valuation, may have an advantage of a higher debt limit.

Another consideration is whether the school district will be able to market bonds after the bond issue referendum has passed. The supply and demand in the money market, the level of bond interest rates, and the districts' bond rating will control the school district's ability to sell bonds.

If the debt limit and bond market is favorable, a bond proposal is drawn up and a bond issue referendum is called to authorize the school district to sell bonds and raise the taxes necessary to pay for them. If the bond issue passes, the school district sells the bonds to obtain the cash to pay for the building project. If the bond issue fails the school district must reconsider the proposal and determine other means of financing.

The most difficult part of this method of financing is drawing up a proposal to be presented to the voters. The proposal must be carefully developed to prevent misunderstanding of the true needs of the school district. It must contain complete justification for the financial needs and what completion of the project will bring to the

community as well as results if the bond issue does not pass. Good communications with the public can win the bond issue for the school district. Time spent in communicating is extremely important and should not be taken lightly.

Leasing

No state prohibits leasing, but the duration or term of leasing is regulated by some states. Long-term leasing is usually ruled out unless approved by referendum. In some states, the school district is permitted to take 30-year leases without voter approval.

Leasing may be necessary in cases where the school districts have reached debt limits or cannot pass new bond issues. If the need for space is temporary, the most economical solution may be to lease or rent the space. This may occur in a school district where the enrollment projections show temporary increases, which would not justify new facilities. Leasing for long terms may be a disadvantage to the students because the school district may be prevented from making necessary changes in the facility to accommodate the curriculum and instructional techniques.

Some school districts lease property with the option to purchase with rentals applying to purchase. This permits the school district to purchase on a time-payment plan without assuming any long-term debt. Leasing is a popular option for school districts where financing is difficult and a real need for additional space is justified.

Conclusions

The effective budgeting of annual and long range needs, together with good project planning for capital improvements is basic to the overall success of the total financial program. It leads to economies in financing the capital debt. It is extremely important that those responsible for educational facility planning and budgeting be aware of the budgeting process and the alternatives available for financing capital improvements.

CHAPTER VIII
EVALUATION OF EXISTING FACILITIES

Evaluation techniques

It is as necessary to constantly evaluate industrial education facilities and equipment as the curricular programs. Facilities and equipment do not remain indefinitely capable of satisfying course objectives. Industry is dynamic and changes are occurring constantly which affect emphases of industrial education.

It is suggested that existing facilities be evaluated each year to determine quantitative and qualitative program adequacy. Quantitatively, the concern is whether existing facilities can house the projected maximum student enrollment, the number of years the facility can be utilized before expansion is necessary, and the size and number of areas needed for existing and expanding programs. Qualitatively, the concern is whether existing areas facilitate or constrain the desired program and whether facilities and equipment adapt to program changes without undue expense.

The starting point for any evaluation is to determine whether the facility can accommodate the planned program. If not, it is time to modernize or build a new facility.

An accurate appraisal must be made of the physical condition of the laboratory before recommendations may be made. The condition of floors, walls, windows, ceilings, and utilities must be examined periodically to determine their worth to the educational program.

A comprehensive evaluation checklist can serve as an instrument to determine the worth of existing facilities. There is no best form of evaluation checklist. It is sometimes better for the person doing the evaluation to prepare his own evaluation form. However, there are key items that are sometimes forgotten. The checklist should be thorough and cover all aspects of facility design and specifications as related to the implementation of a curriculum. Some items should be compared against accepted standards rather than just a good or poor rating. Space should be provided for comments and suggested changes for each item on the evaluation checklist.

The checklist can be not only useful in judging facilities that are now in use, but should be helpful in presenting a case for new or modernized facilities. A good argument may be made for modernization by showing how the facility compares against the elements found on the checklist.

The checklist may also be used in the process of planning new facilities by checking off various items against plans and specifications for a new building.

The following checklist is recommended merely as a guide for use in evaluating facilities. Program must be considered as the checklist is used because the facility is being evaluated to determine if it can serve the planned program.

PHYSICAL FACILITIES EVALUATION
FOR INDUSTRIAL EDUCATION

SCHOOL _____ DATE _____

LOCATION _____ EVALUATOR (S) _____

_____

TYPES OF SHOPS

General _____ Communication _____ Power / Energy _____

Materials / Processes _____ Manufacturing _____ Construction _____

Drafting _____ Electricity / Electronics _____ Woods _____

Metals _____ Plastics _____ Auto Mechanics _____ Graphic Arts _____

Other _____

LOCATION

A. Shops are located on the ground floor. (Standard — Ground)

B. Shops are accessible from both the outside of the building and the main school corridor. (Standard — should be for safety and material deliveries)

C. Shops are positioned so they are adjacent to one another. (Standard — should be for best intradepartmental organization.)

SPACE

A. Record shop dimensions. Give width, length and area. (Standard — Refer to Chapter IV.)

B. Compute area for each student. (Standard — Refer to Chapter IV.)

C. Show positioning of space. (Attach a sketch or blueprint of layout.)

D. Flooring materials meet standards. (Standard — wood or tile, except in hot metals area it should be concrete or asbestos.)

E. Walls meet standards.
   1. Wall space is adequate. (Standard — 6′ high clear space)
   2. Walls are finished to height of wainscoting (Standard — 6′, hard plaster, painted or glazed material.)
   3. Windows are at proper height. (Standard — sill height 6′ from floor.)
   4. Acoustical treatment is adequate. (Standard — acoustically treated plaster or acoustical blocks.)

F. Ceilings meet standards.
   1. Height is 14 feet. (Standard — 14′)
   2. Acoustical treatment is adequate. (Standard — acoustically treated plaster or acoustical blocks.)

G. Doors are adequate.
   1. Width of corridor doors to shop (Standard — 36″)
   2. Number of doors leading out of shop (Standard — 2)
   3. Service door (Standard — overhead or double door)
   4. Width of service door (Standard — 96″)
   5. Type of hardware on doors (Standard — panic bar)

H. Display or exhibit area. (Standard — 24 cubic ft. enclosed case)

I. Fire protection.
   1. Extinguishers
      a. Types (Standard — dry chemical and carbon dioxide)
      b. Height of mounting (Standard — Less than 40 lbs. top of extinguisher not over 5 ft. More than 40 lbs. top of extinguisher not over 3 1/2 ft. from floor)
      c. Distance (Standard — maximum 10 ft. from storage of flammable materials and less than 75 ft. from any location in the laboratory.)
   2. Fire blanket (Standard — located adjacent to hot metals area, mounted on wall)

J. Restroom facilities (Standard — located in or near lab)

K. Color dynamics (Standard — see Appendix B of this guide)
   1. Are color codes being used on the following.
      a. machines
      b. walls
      c. ceiling
      d. electrical
      e. fire
      f. first aid

The following factors should be rated as follows: 1—excellent, 2—acceptable, 3—average, 4—needs improvement, 5—poor. Comments should be made where applicable to assist in clarifying the situation.

LAYOUT	RATE	COMMENTS
A. Flexibility.		
1. Equipment can be readily moved as need for change arises.		
2. Individual drives are on all machines.		
3. Partitions are constructed to provide maximum flexibility.		
4. Doorways are provided between shops.		

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	RATE	COMMENTS
B. Pupil work stations are sufficient in number and are arranged so that interference with adjacent workers and aisle travel are minimized. C. Aisles of travel are distinctly marked and provided between all areas and points of common usage such as storage rooms, tools, machines, doors. D. Space is being utilized to its maximum capability.		
INSTRUCTIONAL AREAS A. A separate room is provided for classroom instruction. B. Suitable space in the shop is provided for instruction. C. Suitable furniture is provided in an instructional area. D. Audio-visuals can be used in classrooms. E. Space is designed for multi-use such as planning, library, etc.		
PLANNING CENTER AND/OR LIBRARY A. Area is provided and equipped for student planning. B. A technical library is available. C. Library materials are up-to-date. D. A center is available for individualized learning packages.		
INSTRUCTOR'S AREA A. Separate office space is provided. B. Size (Standard — 100 sq. ft./teacher) C. Office commands full view of shop. D. An area is equipped with essential furniture. E. Privacy is available for student conferences.		
CHALKBOARDS & BULLETIN BOARDS A. Chalkboard size (Standard — 4′ x 8′) B. Bulletin board size (Standard — 4′ x 8′)		
FINISHING ROOM A. Size (Standard — 150 to 200 sq. ft.) B. Ventilation (Standard — 12″ dia. duct with fan exhaust.) C. Fireproof/lockable storage cabinet for flammable materials. D. Spray painting capability. E. Flocking capability. F. Dustproof. G. Shielded electrical outlets & light fixtures. H. Fire extinguisher within 10 ft.		
STUDENT PROJECT STORAGE A. A separate room is provided. B. Room size (Standard — 200 to 300 sq. ft.) C. Locker space is provided (Standard — two students per locker)		

RATE	COMMENTS

STORAGE ROOMS

A. Small tool and parts storage is available.

B. Large material storage is provided.

C. Storage areas are easily accessible to doors for unloading incoming materials.

D. Storage is accessible for supplying areas in which materials are needed so that students pass as few other students and machines as possible.

EQUIPMENT

A. Equipment is movable (flexibility).

B. If machines are movable, space is available to move machines to different locations.

C. Material handling equipment is available for moving machines.

TOOL STORAGE

A. A tool room is provided.

B. Tool panels are provided for each general area represented.

C. Tools are easily accessible.

D. Control of tools is adequate.

E. Tool panels are marked to identify positioning of tools.

F. More tool panels can be positioned if needed.

MECHANICAL SERVICES

A. Heating adequate to meet standards. (Standard — 65 to 70 degrees)

B. Air ventilation system is capable of circulating fresh outside air.

C. Dust exhaust system
   1. Has flexible connections and is efficient.

D. Fume exhaust system
   1. Is positioned over hot metals area and welding booths.
   2. Is efficient.

E. Lighting
   1. Effectiveness is adequate. (Standard — fluorescent)
   2. Supplemental lighting is provided on machines where applicable.

F. Electrical
   1. System is adequate for machines.
   2. Bus-ducts meet standards. (Standard — 120/208v)
   3. Flexibility is provided by the system.
   4. Perimeter outlets are adequate for general use.
   5. Panic buttons are available where they are determined to be necessary.

G. Compressed air system
   1. Pressure psi (Standard — 125 psi)
   2. Volume adequate (Standard — 150 cfm)
   3. Sufficient air outlets.
   4. Gauges attached on used outlets.
   5. Shut-off valve in lab.
   6. Compressor outside lab.
   7. Moisture trap in lines.

RATE	COMMENTS

H. Gas system.
   1. BTU per hour sufficient.
   2. Shut-off valve in lab.

I. Water system.
   1. Wash sink provided.
   2. Slop sink provided.
   3. Drinking fountain provided.
   4. Floor drains, where applicable.
   5. Hot & cold water available.
   6. Temperature control on darkroom sink.

DARKROOM FACILITIES

A. Size (Standard — 100 to 200 sq. ft.)

B. Sufficient bench area for working.

C. Storage space for film. (Standard — refrigerator)

D. Sink (Standard — stainless or fiberglass)

E. Enlarger available.

F. Horizontal or vertical camera.

EQUIPMENT & MATERIALS

A. Machines
   1. Unit type. Provides maximum efficiency, safety, and flexibility.
   2. Designed and used for only one type of processing.
   3. Mounted on individual bases.
   4. Fastened to floor, where needed by permanent means or vacuum pads.
   5. Sufficient size or capacity to take care of the bulk of the activities in the lab.
   6. Size of machines corresponds with the age of students using them.
   7. Essential safety features such as pulley & belt guards.
   8. Moving parts on machines guarded.
   9. Machines are provided with effective guards over cutting heads and areas.
   10. Guards are of clear material so operator can visually see material.
   11. Good lighting around machines.
   12. Motors are equipped with overload protective devices.
   13. Machines are in good working order.

B. Auxiliary equipment.
   1. Clean-up area provided.
   2. First aid equipment available.
   3. Phone located in lab or office.
   4. Safety glasses available.

C. Supplies.
   1. Instructional materials available to the teacher.
   2. Student supplies sufficient.
   3. Maintenance supplies available.

D. Maintenance.
   1. Maintenance handled by teacher.
   2. Maintenance handled by others.

E. Hand tools.
   1. Adequate assortment for work areas which are provided in the lab.

EQUIPMENT EVALUATION:

QUANTITY DESIRED	EQUIPMENT DESCRIPTION	NO. IN LAB	ALTERNATE EQUIPMENT
1	Lathe, metal 8″ or larger		
1	Horizontal milling mach.		
1	Vertical milling mach.		
1	Drill press, floor 15″		
1	Drill press, bench 15″		
1	Power cutoff saw		
1	Bandsaw, wood 20″		
1	Bandsaw, metal 20″		
1	Grinder, pedestal 6″		
1	Buffer, pedestal 6″		
1	Shears, metal 24″		
1	Box & pan brake, 24″		
1	Sheet metal rollers, 24″		
1	Bender, ½″ capacity		
1	Foundry tool set		
1	Soldering furnace		
1	Crucible furnace		
1	Spot welder		
1	Gas welding equipment		
1	Arc welding equipment		
1	Shaper, metal 8″ or larger		
1	Jointer or Uniplane		
1	Surfacer, wood 12″ or larger		
1	Lathe, wood/metal spinning		
1	Disc sander 10″		
1	Belt sander 4″ x 48″		
1	Comb. belt/disc sander		
1	Table saw, 8″ or larger		
1	Radial saw, 10″		
1	Shaper, wood		
1	Router, portable		
1	Saber saw, portable		
1	Skil saw, portable		
1	Belt sander, portable		
1	Finishing sander		
1	Drill, electric ¼″ or larger		
1	Platen press		
1	Offset press		
1	Process camera		
1	Photo enlarger		
1	Darkroom developing equip.		
1	Offset exposure unit		

QUANTITY DESIRED	EQUIPMENT DESCRIPTION	NO. IN LAB	ALTERNATE EQUIPMENT
5	Silk screen frames		
1	Light table		
1	Paper cutter		
	Drafting tables w/machines		
1	White printer & developer		
1	Portable air compressor		
1	Pneumatic drill press feed		
	Air cylinder assortment		
	Hydraulic cylinder assortment		
1	Hydraulic pump		
1	Spray gun		
1	Spray booth		
2	Tool storage cabinets (floor)		
2	Wall tool storage cabinets		
1	Finishing cabinet		
2	Small parts cabinets		
1	Lumber rack		
1	Metal storage rack		
1	Type storage cabinet		
1	Injection molding machine		
1	Thermoforming machine		
1	Rotational molder		
1	Compression molder		
1	Laminating machine		
1	Dip molding oven		
1	Numerical control machine		
1	Powder metallurgy machine		
1	Electrical discharge mach.		
	Basic electrical energy trainers		
	Electronic trainers		
1	Fluid power trainer		
1	Mechanical transfer sets		
1	Ceramic kiln		
1	Conveyor unit		
1	Mortiser		
1	Material tester, universal		
1	Plastic/rubber hardness test		
1	Alloy detector kit		
	Benches for 15 work stations		
6	Vises (wood & metal)		
6	C-Clamps		
6	Bar Clamps		
1	Pop Riveter Set		
1	Modular Machine building block mechanisms		

QUANTITY DESIRED	EQUIPMENT DESCRIPTION	NO. IN LAB	ALTERNATE EQUIPMENT
15	Quick acting jig & fixture toggle clamps		
1	Electric typewriter w/carbon ribbon		
1	Refrigerator		
1	Rocket energy tester		
1	Solar cell tester		
1	Fuel cell tester		
1	Outboard motor test tank		
	Automotive instruction models		
	Small gas engines		
	Automobile engines		
1	Emission analysis trainer		
1	Small engine test bench		
	Engine & transmission stands		
1	Automotive test equipment		
1	Tune-up console for auto		
1	Automotive parts washer		
	Automotive body repair equip.		
1	Dynamometer		
1	Display cabinet		
1	Overhead projector		
1	16mm film projector		
1	35mm slide & filmstrip proj.		
1	8mm single concept film proj.		
1	Tape recorder		
1	Television		
1	Video tape recorder		
1 ea.	Instructor's desk, chair, file cabinet, & planning table		

CHAPTER IX
MODERNIZATION

Reasons for modernization

With the cost of construction high and limited financial resources for building, many school districts must turn to modernization programs rather than new construction. With the current decline in enrollments, many school districts now need to assess the physical and educational adequacy of existing plants. In many cases they have old, often unsound, educationally obsolete buildings where maintenance programs have been deferred for budgetary reasons. (54, p 1)

There is no one formula for evaluating facilities. It is suggested that if the total estimated cost of modernization is 50 percent or less of the estimated cost of replacement, it is wise to re-evaluate the old facilities. This is based on a life span of twenty to thirty additional years for the building. (27, p 151) The projected life of the building will have a major part to play in the decision. It is not practical to put money into a structure for which more money will have to be spent again in a few short years.

A primary question that should be asked is whether the facility, when up-dated, can house the required educational program. If the answer is "no" then the facility should be replaced. If new facilities are out of the question, old facilities may be up-dated to serve the objectives of the program. On the other hand, the old facilities may be so outdated that it becomes difficult to implement a program for the student enrollment regardless of remodeling.

The problems of modernization vary greatly. The school enrollment may have outgrown the old facility or new courses wanted and needed which cannot be taught in existing facilities. Perhaps the existing structure is not capable of being remodeled because of safety requirements. Safety code requirements differ from city to city and should be thoroughly understood before a final decision is made to build or modernize. For instance, in some cities the regulations require that the entire building be brought up to code if any part of the building is remodeled or touched by a new addition. This can bring about an added expense which may be the deciding factor in deciding that building a new facility would be more economical. Another problem which exists when remodeling is what to do with the students who may be displaced during construction if the modernization program disrupts the present educational program sufficiently to require some relocation of students. It may require leasing space elsewhere or using relocatable buildings during the interim period of time. This becomes added expense for the project. In remodeling, greater limitations are involved regarding space, shape of the room, and equipment. Improvements often place the responsibility upon the teacher and not on consultants or architects. Some of the critical factors in considering improvements are: reorganizing present space for maximum utilization, the addition of new learning experiences, improvement of safety conditions, providing better utility services, and providing better flexibility so courses may be better interrelated.

Redesigning laboratories periodically is a necessity if the educational system is to keep pace with the ever-changing world. Buildings and equipment do not remain indefinitely capable of giving students a relevant education. Even the houses we live in must be kept up-to-date or they will deteriorate and lose their purpose. Remodeling may have to be a compromise in the improvement but it is still a step in the right direction.

Space management

A problem facing the facilities planner is understanding how to control the demand for change and how to accommodate it. If change has become such an ever-increasing reality in the operation of a school facility, then why not accept it as constant and organize to live with it?

Change, as it affects physical facilities, can be controlled through a process known as "space management." It is the art and/or science of managing people, time and money to most effectively use available space. In a school, it is the process of matching students' learning needs (curriculum) with the things of learning (space, tools, aids), placing them within a time frame (schedule) and doing this all within an allotted budget. (10, p 1)

The space management concept is not a new idea. It has been used for years by plant managers in industry when rearranging facilities to accommodate new processes or improvements in efficiency.

Space management is not difficult when there is an awareness of the techniques of space manipulation. All space must be inventoried for its suitability as learning space. There must be an awareness of the space requirements for the various tasks to be accommodated, a knowledge of the manipulable elements available, and an appreciation of the costs involved in such changes.

The easiest space to manipulate, of course, is totally unencumbered space. It may be necessary that the entire space allocated in the existing school for industrial education be cleared of all non-load-bearing walls in order to start with an unencumbered space. It is then possible to begin reallocating space according to the curriculum program planned for the facility. It may be found that a small addition to the present structure is justifiable, especially if the program calls for an expanded curriculum.

This re-allocating of space involves the compartmentation of areas through the use of demountable partition walls, foldable walls, sliding panel walls, or in some cases, a more permanent type partition.

Sequence

It then becomes necessary to accomplish an equipment layout to determine where utility service systems will be located. By opening up space in the beginning, it becomes easier to superimpose modular grid systems in use today

rather than to tailor-make the systems to fit the old structural boundaries. This can be a savings of time and money. Several producers are marketing systems specifically designed for remodeling. These systems include ceiling, lighting, heating, ventilating, air conditioning, electrical, communications, and audio-visual units necessary for the educational environment.

Procedures in modernization are no different than proposed for new construction in Chapter IV of this guide. The only difference is one of a thorough evaluation of existing facilities to determine their worth, functionally and educationally.

A background study should be initiated to determine the educational philosophy, objectives, and curriculum scope and sequence before beginning to evaluate an existing facility. A program description is needed before a determination can be made as to whether the present facility can be modernized to fit the needs of the new program. Even then the facility's functionality and adaptability may be determined to be satisfactory, but the existing facility may not meet the demands of the educational specifications.

Reorganization

In some cases extensive remodeling may not be necessary but only a reorganization of existing space will meet the demands of a new curriculum approach. Many laboratories are not making maximum utilization of available space. Space may be opened up by rearranging machines and equipment. Flexibility may be obtained by providing flexible hose connections to exhaust outlets and connecting flexible plug-in power modules. Integrating the woods, plastics and metals areas into a materials and

FIGURE 12
Junior high school shop before reorganization.

processes laboratory may be done by adding a doorway between areas. New color code schemes, removing obsolete equipment, and converting large benches into smaller units to form different configurations are a few more ways to be used in making an improved facility without great expense. The key to modernization is looking closely at what is already available rather than starting into a large, expensive major renovation or a new facility.

Figures 12 and 13 show a small junior high school shop which was limited in space thus restricting the possibility of giving the students a new program based on a study of industry. The space was only large enough to handle basic woodworking as it existed. With a few minor changes the area became more open and flexible as well as adding some plastics, metals, graphic arts, and a planning center. The reorganization amounted to the removal of some walls and the addition of an overhead service system. Each of the large bench units was split in half to provide work areas throughout the laboratory. The bench units became work modules which could be moved anywhere in the laboratory to form different work area configurations. It was not necessary to provide a lecture space in this shop because it could be done in a separate room.

Evaluating, remodeling, reorganizing, or adding on to present facilities should be considered when building new facilities is not feasible. Whatever the direction, modernization for the intended program and for future changes should always be uppermost in the minds of the planning committee.

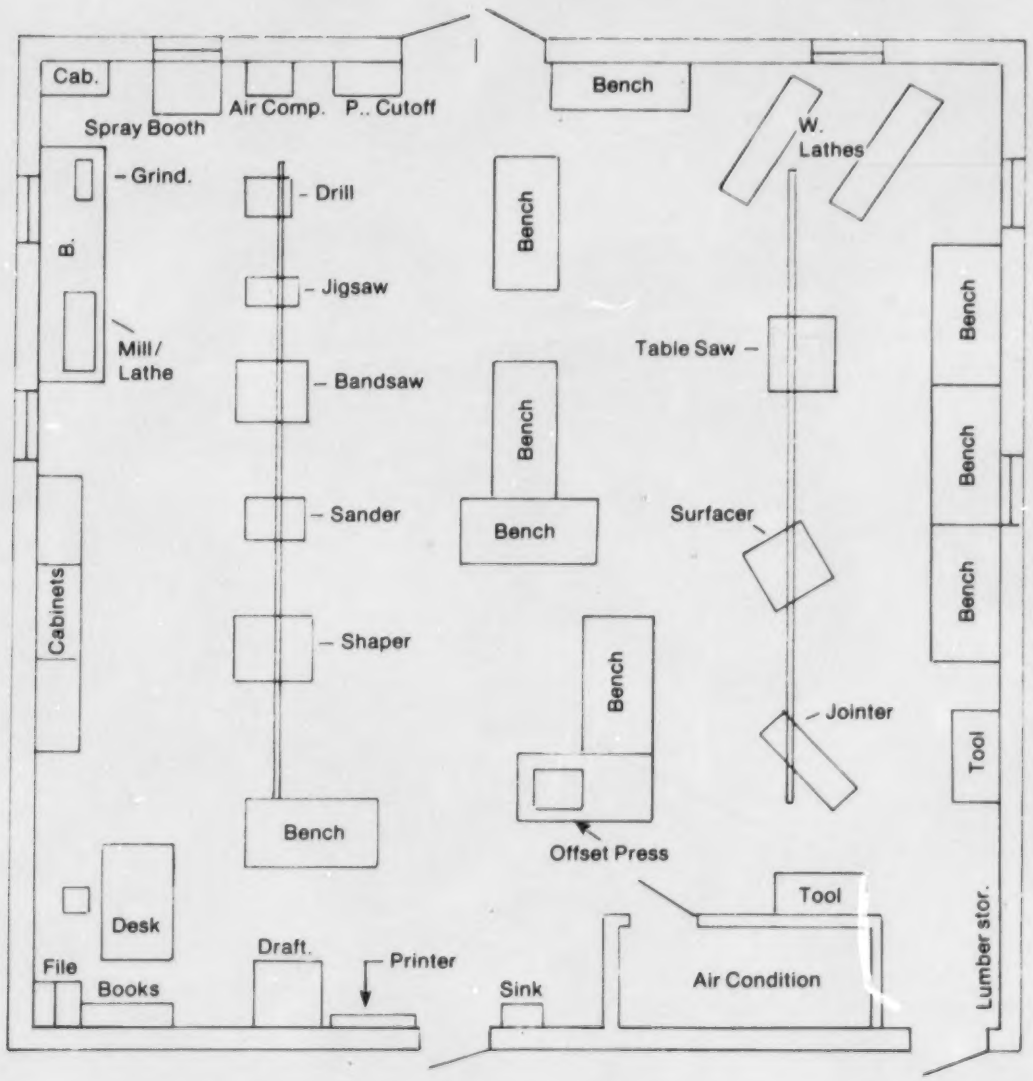


FIGURE 13
Junior high school shop after reorganization.

CHAPTER X
SHARED SPACE CONCEPT

Shared space

A trend in industrial education programs is the shift away from single-career type concentrations and toward career families, technology clusters and a study of industry. Such a shift has been brought about by today's rapid changes in technology. In industry, a metals machine operator may have to expand and be prepared for materials processing and manufacturing concepts. A draftsman may have to be prepared for the visual communication field. The trend is away from the narrow path and toward a broader outlook at the various areas of industrial education.

Since it is improbable that the needs of students having diverse objectives can all be met through a single curriculum available in one laboratory, the trend is toward a curriculum which builds broad skill bases within one or more laboratory clusters. (3, p 5) It is recognized that the cluster concept has merit and provides a broader range of skills needed in today's world. However, it is apparent that specialized laboratories for each career area within industrial education cannot always be afforded. The concept of sharing facilities in order to decrease the cost per use of buildings or equipment through some form of integrated, open laboratory facility is gaining recognition. Planning must be done through understanding the specific objectives and functions which will take place within the space. The plan should be translated into study outlines for specific courses. It must also be determined which stations can be used most successfully for more than one program. This last decision may be most critical to determining which elements lend themselves to sharing and reflecting them into a facility relationship.

The sharing concept is based on the recognition that some basic work stations can form a general service area for several related programs. There can be overlapping laboratories which share common services but have separate areas for specific skill oriented activities. There may also be separate, specialized mini-labs designed around a center core of shared facilities. Two separate, and possibly dissimilar, program areas may share a single laboratory, with a shared general area which supports both programs. Figure 14 illustrates how this might apply to a metal processing general area which serves both the welding and machine shop areas thus reducing total area and the duplication of equipment.

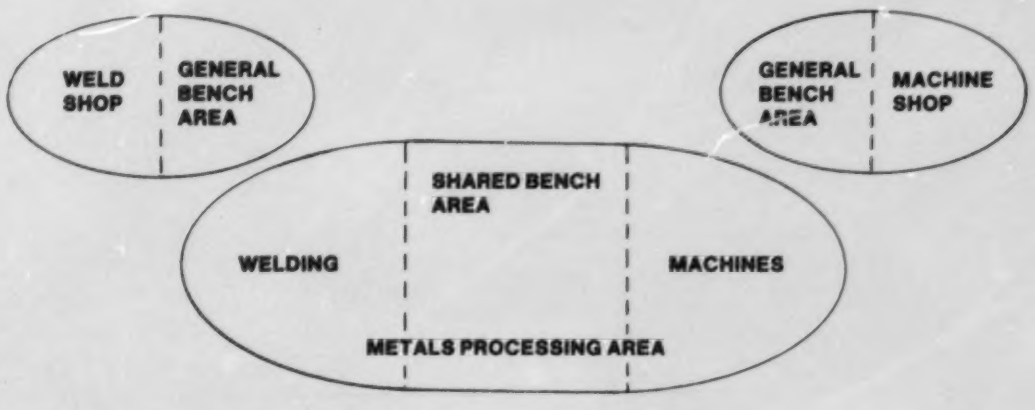


FIGURE 14
Space sharing concept. The general bench area is shared by both areas thus reducing total space needed and eliminates the duplication of machines.

Center core

This concept may also apply to a center core production area surrounded by specific skill areas. The production area serves as the shared area to be used by all surrounding areas to provide an integrated program. The production area would house all machines common to each of the areas in order to eliminate duplication and added cost. (See Figure 15 for the center core concept.)

A core area may serve several disciplines within a cluster. The mini-labs around the core lab can provide the specific content, but the shared area makes best use of systems essential to all mini-labs. This can lead to program unification and provide students the opportunity to be more aware of related areas. It permits flexibility in that programs may be changed in the mini-lab and not affect other areas while maintaining full utilization of the center core area. (See Figure 16 for an illustration.)

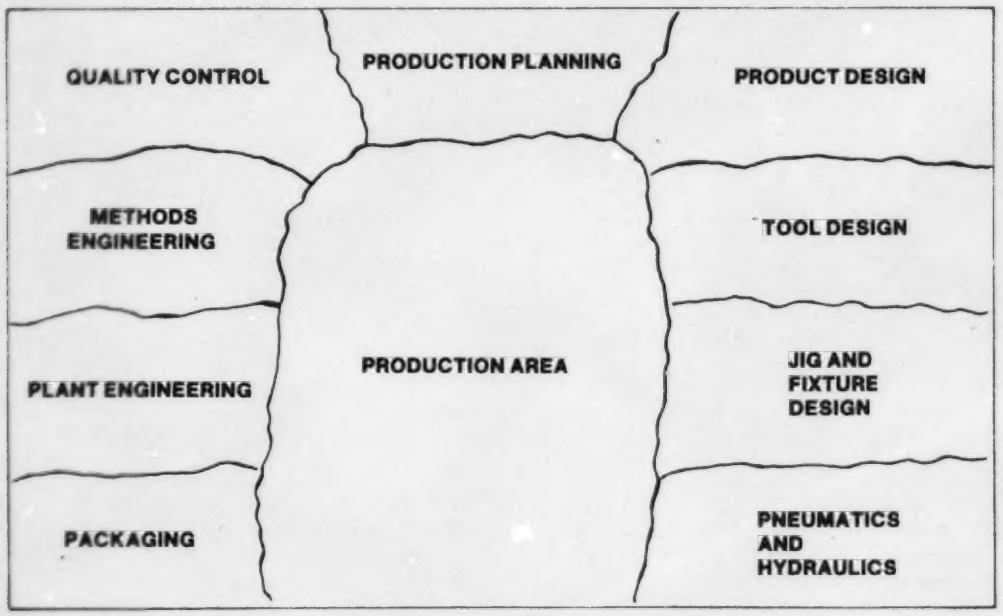


FIGURE 15

Center core concept. The dividing lines merely show separation of areas not walls. The areas may be divided by bench modules or foldable walls.

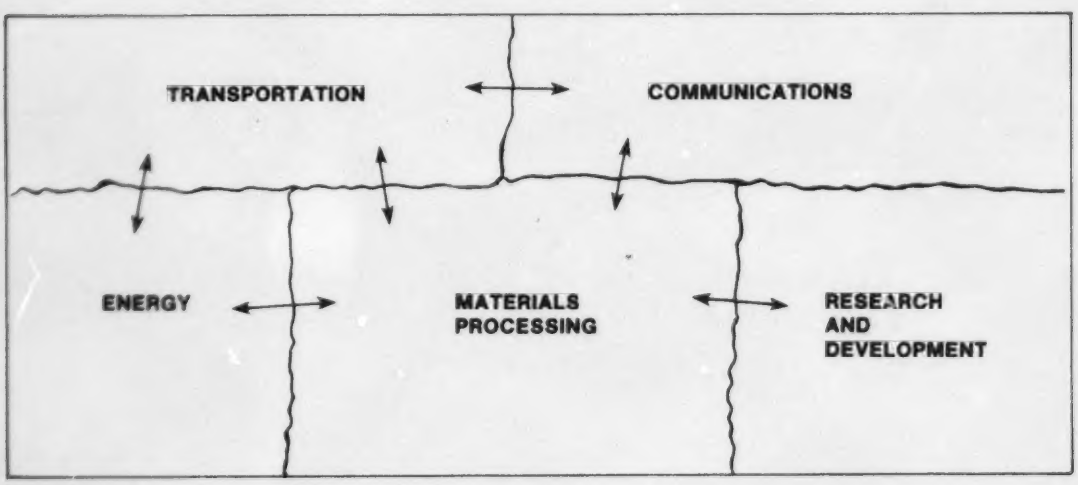


FIGURE 16

Core area with mini-labs. Dividing points should be flexible so areas can integrate.

Space sha. ing with sequential activities

Space shar.ng can bring about a unification of program areas where se quential activities can be scheduled to use a common fabr.cation area. For example, in construction, tradesmen work in the same space. Carpenters or concrete form builders start the sequence; then electricians, plumbers, and sheet metal workers enter the picture to install wiring, pipe, and ducts; interior workers then begin the finishing touches. Again, each surrounding area might serve as mini-labs and the shared space serves to work on a real life situation such as building a structure as a team project. (See Figure 17 for an illustration of this idea.)

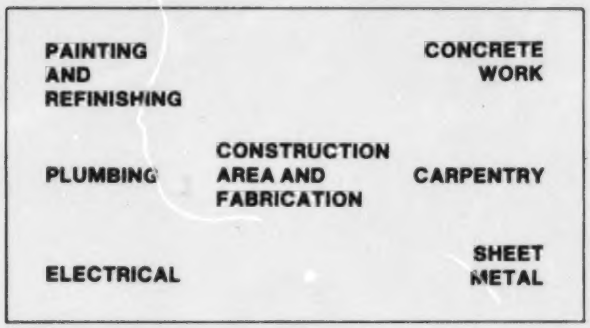


FIGURE 17

Space sharing with sequential activities. No permanent walls between areas so flexibility is maintained.

Small area shared space

In a situation where large spaces are not available, alternate use and storage of different program systems might be an option. This might be used in an elementary situation where the systems cannot remain in the room. Here multiple use of the facility is limited and space conversion time is necessary. However, where the systems are mounted on mobile units or simple material handling equipment is available, the conversion time could be reduced. Larger storage space would be necessary but total space requirements would not be as much as separate laboratories for each program. In an elementary school the industrial education materials and tools could be stored while other areas of the curriculum are being studied. A communication course could be offered which would include program content in visual and audio communication media. Certain equipment systems would be beneficial to all of these programs and could be set up in a space provided. Special systems only necessary for each of the programs would be kept in storage when not in use. These programs might be offered on a nine week rotational basis. (See Figure 18 for an illustration of this approach.)

Sequential with transformation

Some program content is sequential in nature and activities are overlapping, but periods of transformation take place. The space may not convert from one area to another entirely because of time and/or student differences. As a result, the space may transform in stages

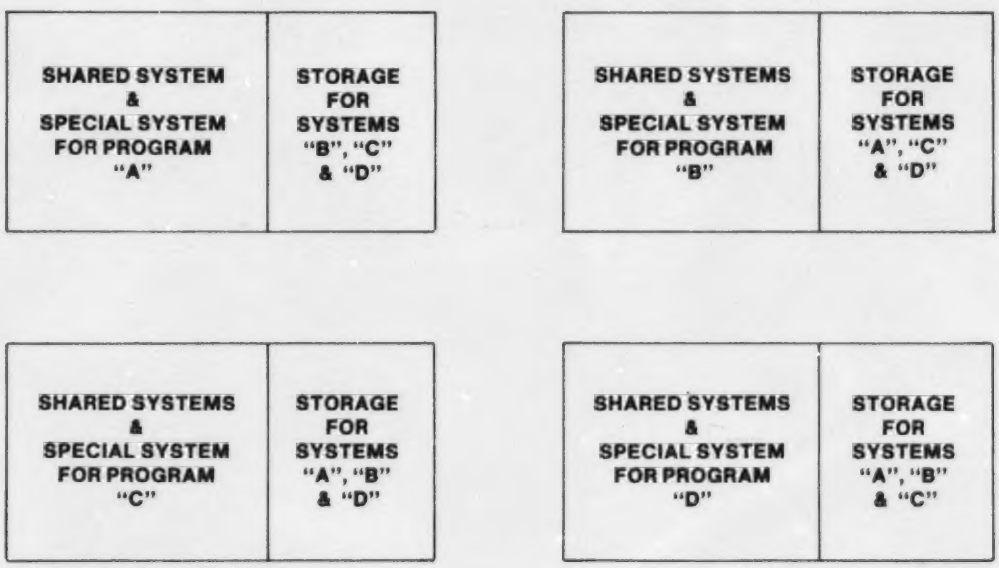

SHARED SYSTEM & SPECIAL SYSTEM FOR PROGRAM "A"
STORAGE FOR SYSTEMS "B", "C" & "D"
SHARED SYSTEMS & SPECIAL SYSTEM FOR PROGRAM "B"
STORAGE FOR SYSTEMS "A", "C" & "D"
SHARED SYSTEMS & SPECIAL SYSTEM FOR PROGRAM "C"
STORAGE FOR SYSTEMS "A", "B" & "D"
SHARED SYSTEMS & SPECIAL SYSTEM FOR PROGRAM "D"
STORAGE FOR SYSTEMS "A", "B" & "C"

FIGURE 18

Alternate use and storage of different program systems. Special systems would be stored on movable modules and transferred into the main area when studying that particular system. Shared systems would remain in the main area all the time.

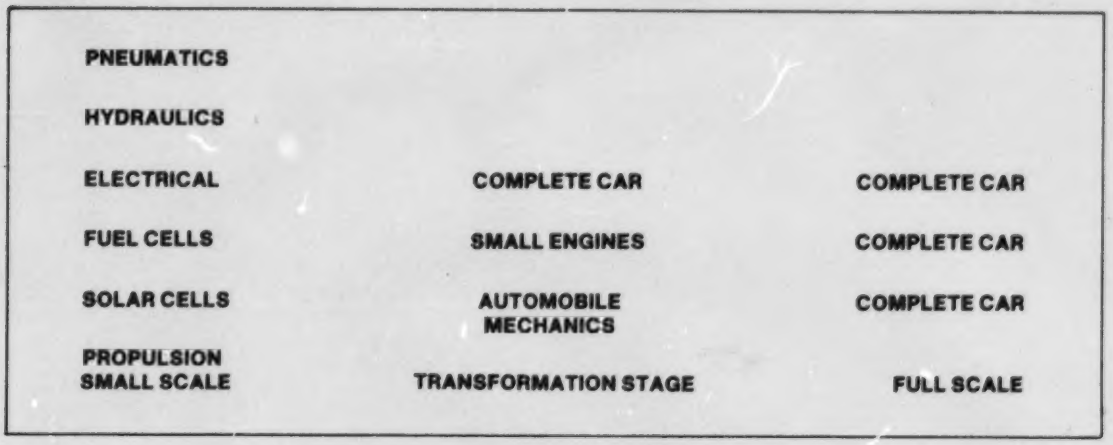


FIGURE 19

Transformation of space systems. This may be considered as one laboratory being converted as the program progresses or as one laboratory divided into three stages.

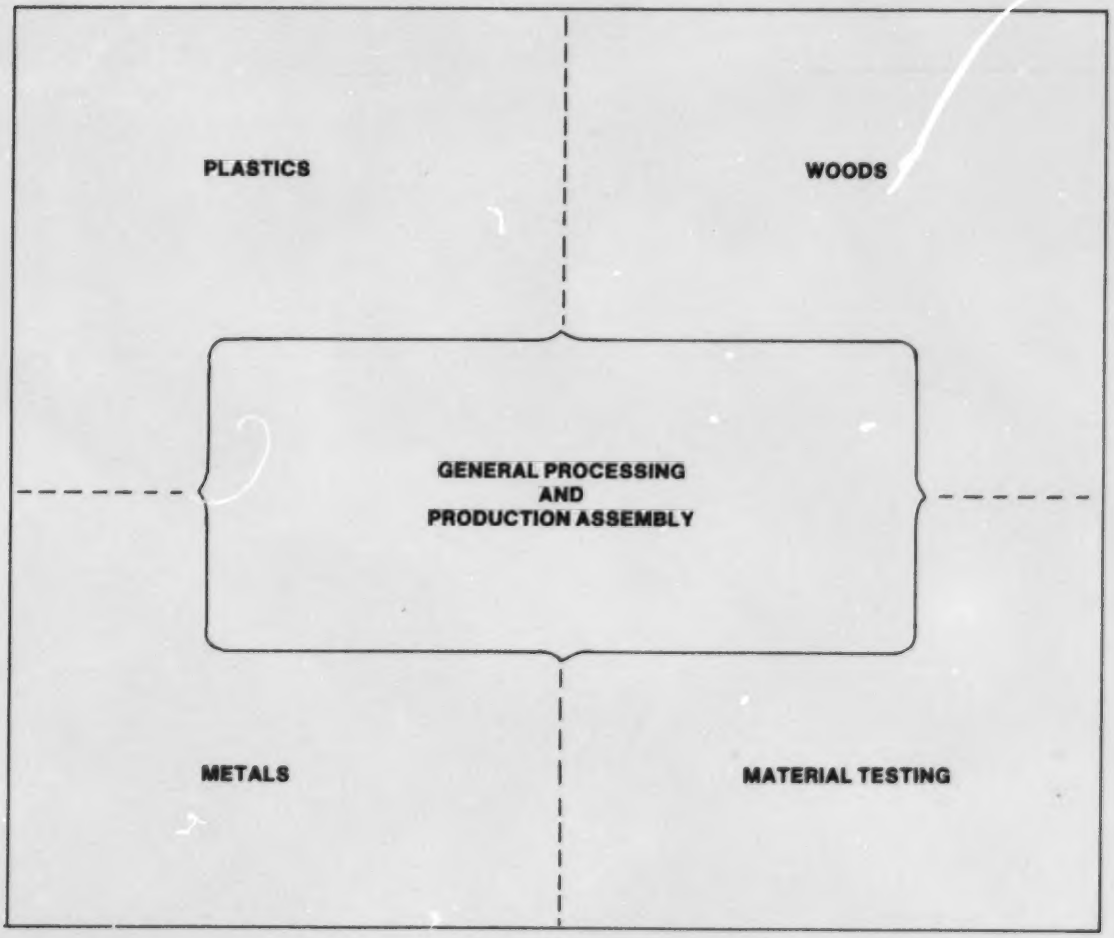


FIGURE 20

Designed originally to be primarily a woods and plastics laboratory but with future space planned to expand to develop a materials and processing laboratory including the potential of production type activities.

over a period of time. For example, a power and energy course may include fluidics, electrical, small engines, and automobiles. The first stages may be basic skills in electrical and fluidics with students working on smaller scale systems utilizing less open space but in need of bench space. They may then begin to transfer over to small engines and eventually into automobile engines. As the program progresses to more full scale systems, larger space is necessary and space transformation becomes essential. One large laboratory may even be sub-divided into the various types of systems necessary for the entire program. (See Figure 19.)

Spin-offs

The shared space concept tends to draw together disciplines with common features, thereby permitting students to gain knowledge and learning experiences in more widely related areas rather than narrow concentrations. This enables the student to be better prepared for career changes later in life, should the situation arise and to gain a more balanced understanding of industry and technology. Many times a student never becomes associated with the related areas because his concentration is too intense in one part of a total program.

This drawing together also permits spin-offs of new programs being offered at later dates by making use of existing facilities. These increases in program offerings can usually be made with minimum expenditures. This is where space planning in the beginning is critical so that future programs can be added without major expenditures for additional space. A manufacturing laboratory may be designed in the beginning, because of budget, to primarily handle wood processing but may provide space flexible enough to permit other material processing activities in the future. As money becomes available, metal, plastic, ceramic and other materials may be added without additional cost for space. A finishing room adjacent to both wood and metal areas might be designed originally to handle basic finishing requirements, but space may be provided for spin-offs such as flocking, anodizing, or plating in the future. A photography program might be a spin-off as a result of a darkroom planned into the communications laboratory. (Figures 20 and 21 illustrate this spin-off approach and the adding of content areas in the future.)

The concept of shared space should not be overlooked as an alternative in space planning for an industrial education facility. Space saving, as well as not duplicating equipment needs, results in financial savings for the school district and provides good justification for the shared space approach. However, one should not permit the concept to limit the facility necessary to carry out a complete program according to educational objectives and student needs. Once space is decreased, restrictions are placed on the present program and future program additions. This space is almost always difficult to regain.

The key to planning shared space facilities is in being able to select those functional areas which may be shared and having a list of functional areas not just for the present program but for the future.

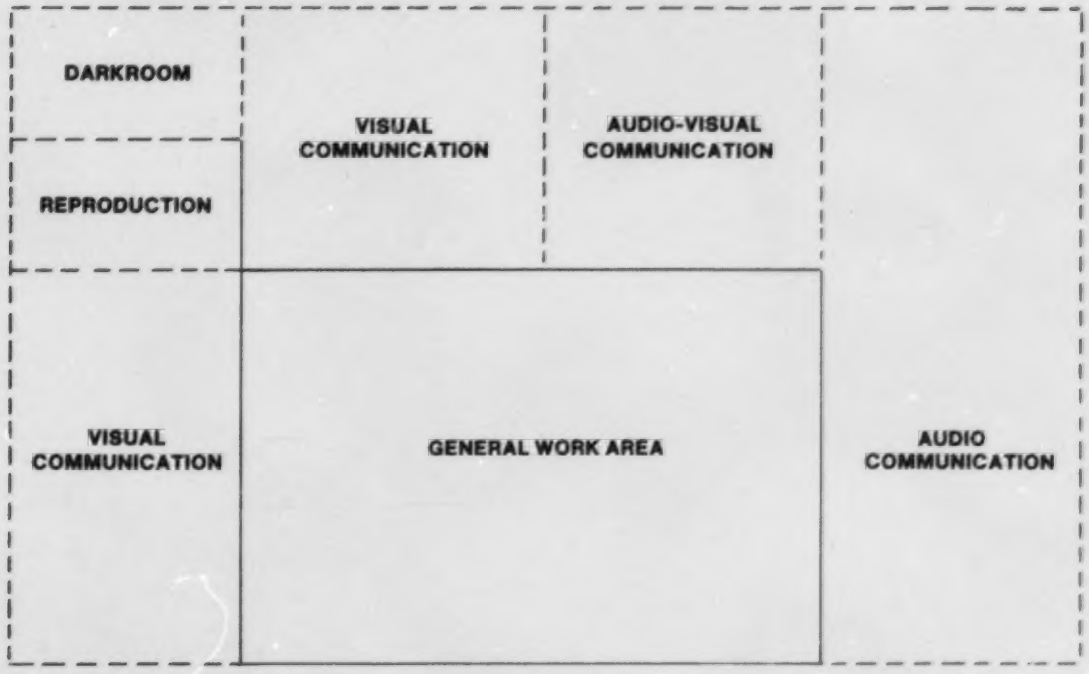


FIGURE 21

The general work area was originally designed as a drafting area but spin-offs might occur which would require only a slight increase in space to provide a comprehensive communications laboratory.

CHAPTER XI
ALTERNATIVES

Everyone must be willing and able to live with change each day. When changes occur, people must make decisions according to the effect of these changes on their particular situation. This decision making entails a careful look at alternatives which are available. When a school district's enrollment increases to a point of over-crowdedness, a decision must be made to expand the present facilities, build new facilities, or find a better way to use the existing facilities. The same applies to a business enterprise. When a company decides to market a new product or service they must decide whether or not to build new facilities, find existing space elsewhere, or expand their present facilities. In each case they have alternatives from which they must select the one which will give them the best return on their investment.

When an industrial education committee decides it is time for a change in the curriculum, it too has alternatives.

Instructional techniques

In some cases the alternative may be to change the instructional technique so as to provide a better learning opportunity for students, without doing anything to the facility. With this alternative we must rely heavily on our facility evaluation process to see if the present facility will efficiently and effectively provide all which is necessary to accomplish the new and changing objectives of the program. There are many facilities where only minor reorganization will accomplish the necessary changes to provide an environment in which the new program can be implemented. The only real change becomes one of instructional methods. For instance, instead of individual projects the technique becomes one of establishing a student enterprise to plan, develop, and market a product in order to gain an understanding of the concepts of industry.

However, with some program changes more space must be found to accommodate the increase in course offerings and to provide a broader foundation for the industrial education program.

If a new facility seems feasible, then the school district must decide if it will be a concentrated center where all areas will be together or smaller centers located at different sites with each center specializing in different aspects of industrial education. If present facilities are to be used, will it mean adding needed space or modernizing existing space to fulfill the requirements of the new program?

Another method may be to find existing space in the school district such as a warehouse, old plant, office building or some other building which could be modernized to serve the new industrial education program. Regardless, it is important that the school system look into all options available. There is no one answer to a facility problem. We live in a diversified world with rural, urban, suburban, industrial, agricultural, recreational and a variety of other considerations. One type of facility will not satisfy all the desires and expectations of the multitude of community situations. However, we want to be certain that all alternatives are given consideration.

Center approach

A wide variety of industrial education offerings are concentrated under one roof. This may be at each secondary school or centralized to serve several schools. This system is easiest from an administrative standpoint because it is concentrated. Where it is serving several schools it may be administered by its own staff. There may be conflict with the staffs of the schools being served. (See Figure 22 for an example of the center approach.)

The center approach can provide a laboratory sharing concept to be implemented between certain course offerings. In the one case it would eliminate the repetition of building at each school although it does provide a transportation problem. The center approach may provide exposure to a multitude of educational experiences and opportunities to integrate course content. The center approach most often used is where the entire curriculum is offered at each school because of administration and transportation problems associated with the separate center approach.

Multi-centers

This method would take considerable coordination and cooperation with each school taking part in administering certain aspects of an industrial education program. Each school in the system (or they may be from different systems) would offer a different area of concentration within the industrial education curriculum. (See Figure 23 for an illustration.)

The multi-center approach provides for greater, in-depth study of each concentration but has the problem of transporting students from school to school. It eliminates much duplication of equipment, although some duplication would be necessary. It eliminates completely the opportunity of integration of the areas. Some students may never see the possibilities offered in other areas of the industrial education program.

Technical satellites

A fourth alternative is to establish technical satellites located in business and industry where a student may obtain first hand experiences in areas of manufacturing, energy, construction, and communications. This plan would take considerable coordination with the cooperating enterprises but is an important option for some school districts. Basic industrial education space would still be required in each high school, but the in-depth content would be handled by the satellite centers. These satellites may be located within an industrial park where cooperative education possibilities are closely associated with the

educational program. Several schools could use the satellites to eliminate repetition. (See Figure 24 for an illustration.)

Remodeling

A fifth alternative to be considered is space within existing educational facilities. This is the remodeling of the present industrial education shops to meet new objectives, course offerings, and student needs. This would not include additional space but merely the reorganization of what is already available to make maximum utilization of the space.

Existing space within the educational building.

A sixth alternative is to look at existing educational space which could be converted to use for industrial education. Many times a school has built a new gymnasium, auditorium, or cafeteria which may make old space available for other functions. These open areas may be adaptable for industrial education purposes. Even areas under football stadiums might well be considered for utilization as industrial education facilities.

Existing space in other buildings.

Alternative seven may be to look for existing space in empty buildings located close to the school so as to minimize problems of transportation. Such space might be found in an old office building, supermarket, warehouse, or industrial plant. Buildings with open spaces and good sound structure could, with minor modernization, be an ideal facility for industrial education.

FIGURE 22

Each high school will offer an entire curriculum in industrial education or a centralized industrial education building can serve several high schools.

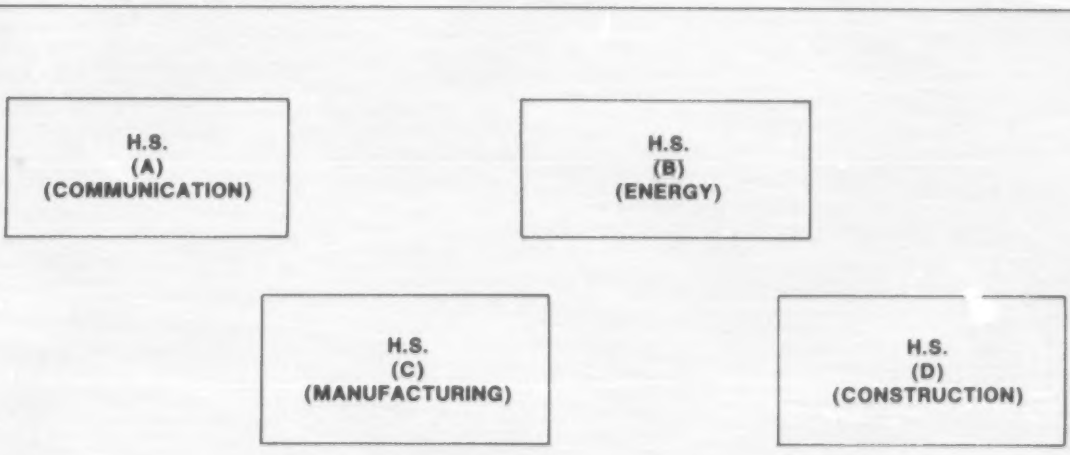


FIGURE 23

The multi-center approach permits each high school in a district to concentrate in one major area of the industrial education curriculum.

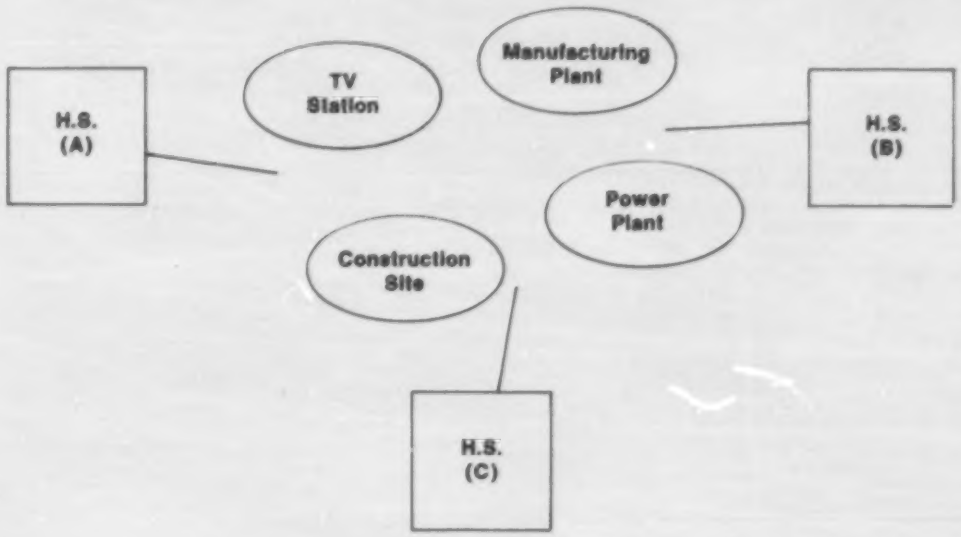
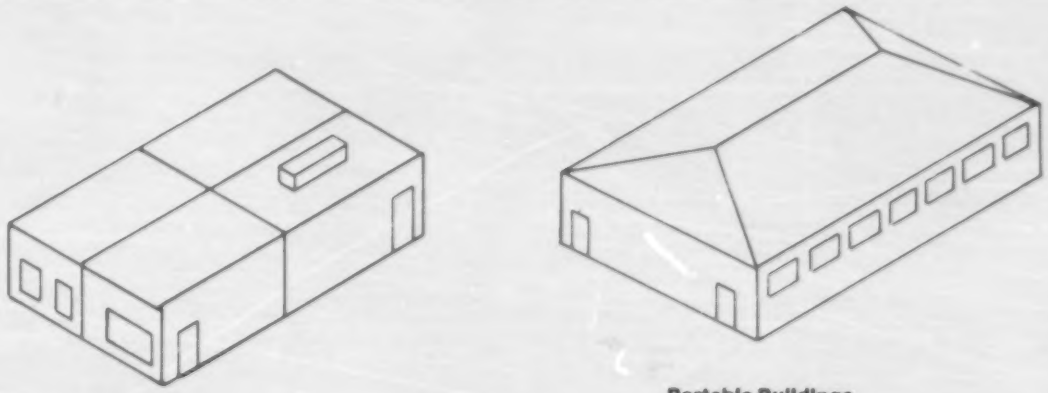


FIGURE 24
Technical satellites are established which are representative of the industrial education offerings. They provide direct experience to go along with the basics taught at each school.



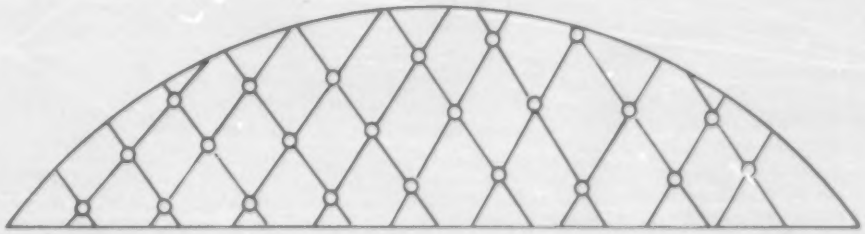


FIGURE 25
Modular and dome structures.

Modular structures

An eighth alternative would be to consider movable or modular structures. Air-supported structures, such as used for the U.S. Pavilion at the 1970 World's Fair, are becoming popular for covering recreational areas and for warehousing in industry. Several educational facilities have made use of the air structure throughout the United States (55) and (56). Domes of aluminum tubing covered with plastic film or canvas might be considered. Demountable buildings assembled from kits which have their own closed systems built-in for utilities could be used for industrial education programs. Each module becomes a self-contained area of the program with capability of integration between areas. (13, p 13) (See Figure 25 for examples.)

Mobile units

Alternative nine may be to consider the advantages of mobile units which move around the school district or between districts. Some school districts do not have a large enough student enrollment to justify the building of a complete industrial education facility. Mobile units may be the answer. Consideration may be given to mobile units which are equipped with industrial education equipment which will supplement a small existing facility in the school. These mobile units may be stationed at different schools in a district for a period of time to provide students with experiences they may not get elsewhere. These mobile units could be equipped with electronic equipment, visual communication equipment, or material processing equipment which the district could not justify placing in all schools because of expense, utilization, and space. Railroad cars or trucks could be equipped with special programs and move from school to school or town to town.

Build new

A tenth alternative is to build a complete new facility to house the industrial education program. This alternative includes building additions or separate buildings. If the school district has old, outdated structures which cannot be adapted to the new programs, then building may be the only alternative.

In view of enrollment, finance, and trends toward more career preparation, a facility planning committee must be aware of the options available to them and balance the options against the educational needs of students now and in future years. Alternatives need to be carefully scrutinized by school districts. Whatever the decision, the student and the program must be considered above all other factors in planning the type of facility needed for the industrial education department.

CHAPTER XII
SELECTED LAYOUTS FOR INDUSTRIAL EDUCATION

Selection layout criteria

Selecting the proper layout for the industrial education department may be just as critical as writing the educational specifications. This responsibility usually is taken by the architect because he must fit all areas together to form a sound architectural design and structure. By observing different layouts, the teacher may gain a general knowledge of configurations which seem to fulfill the needs of industrial education.

The important factors in selecting a layout are: (1) relationship of industrial education areas to other areas in the school, (2) relationship of courses within the industrial education department, (3) detailed layouts of each laboratory, and (4) shape of each laboratory.

The industrial education department should be located on the perimeter or in a wing of a building for easy access. It should be designed into the total environment of the school facility. Locating the industrial education department near other related curriculum areas makes correlated activities easier.

The relationships of unit laboratories within the industrial education department should be carefully studied. In certain areas it may be advantageous to share equipment or combine activities thereby giving justification for them being located adjacent to each other within the department.

Good layout within each laboratory is essential if maximum utilization of space is to be accomplished. There should be good open work space, safe aisle and traffic patterns, plenty of machine operator space, and flexibility.

Layout shapes

The possible shapes for industrial education laboratories are many but a few tend to be more efficient for accommodating industrial education activities and proper supervision. The shape decided upon will depend, many times, on the configuration of the entire building or the existing shape when an addition is made.

Figure 26 shows the basic shapes being used presently for industrial education facilities. Square and rectangular shapes are quite traditional, and still represent the majority of design configurations being used today.

Each of these shapes can be designed into an intricate configuration or combined to form a very interesting facility composite. (Some of these are illustrated in Figure 27.)

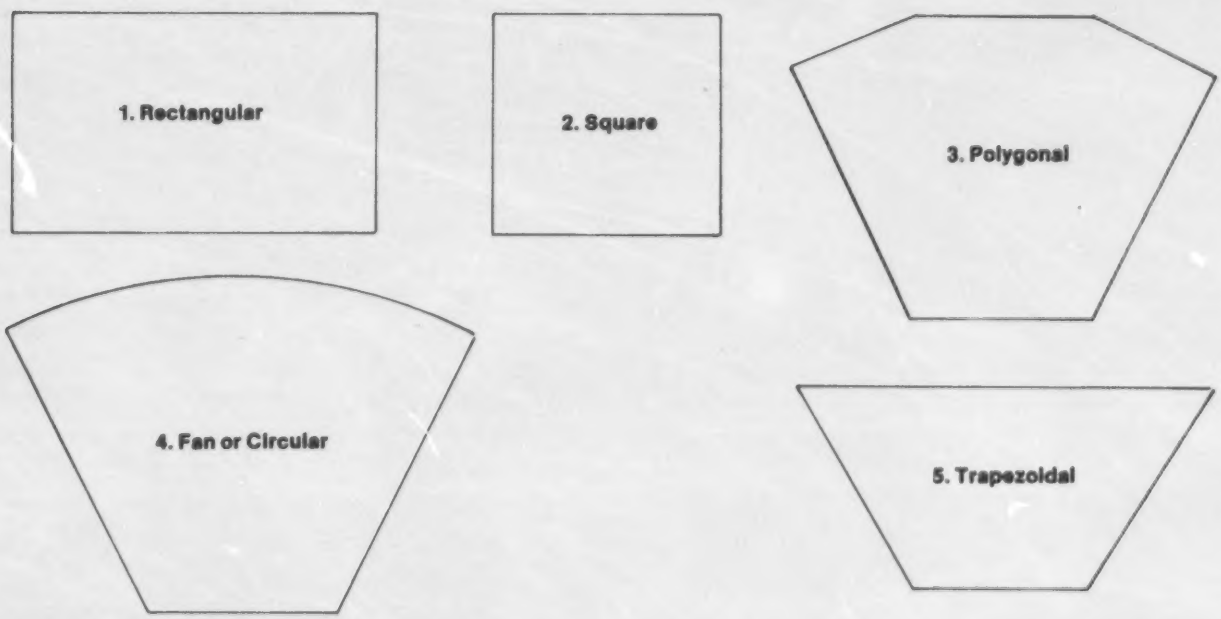


FIGURE 26

Shapes of laboratory layouts which are most commonly used for industrial education.

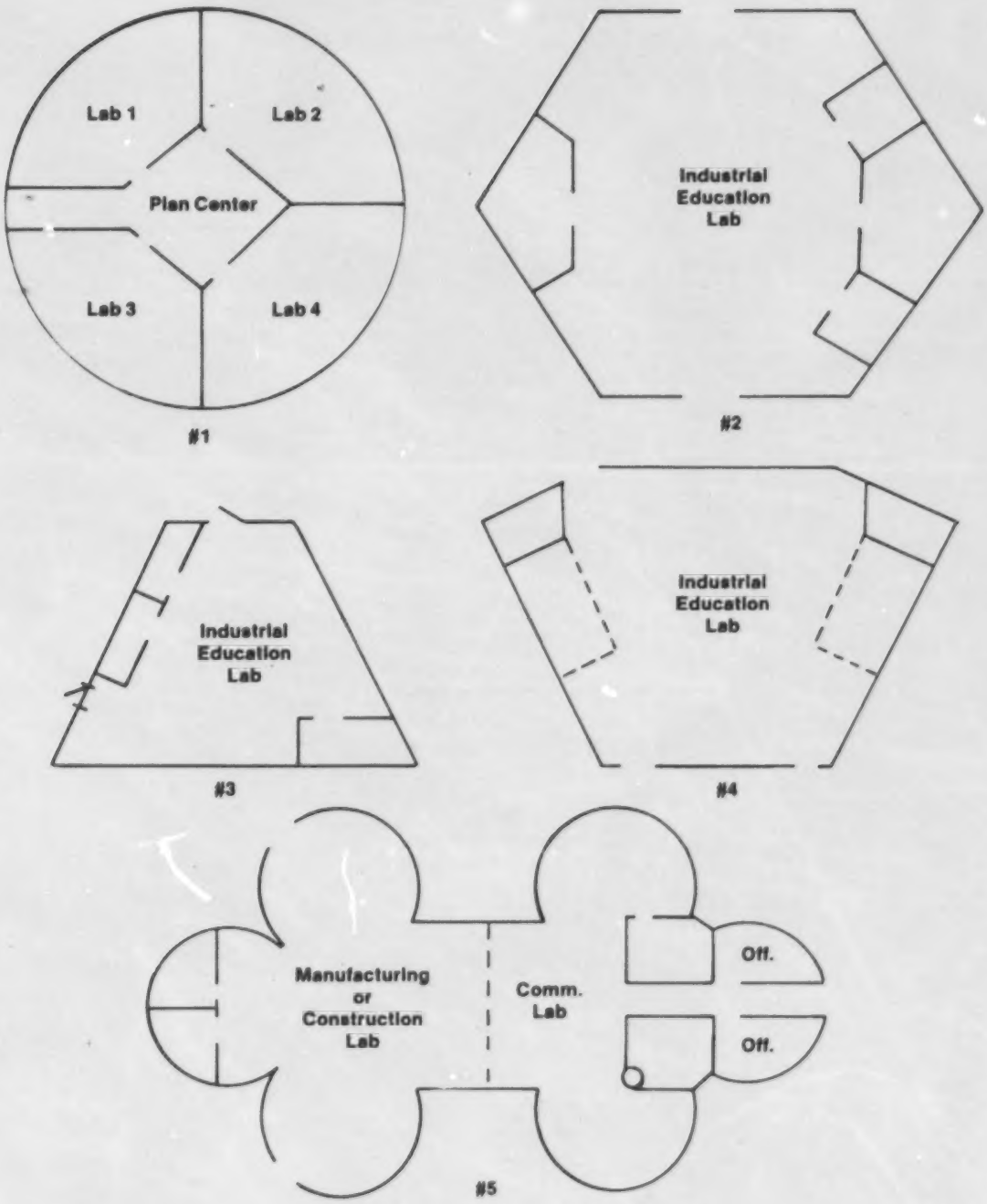


FIGURE 27

Implementation of the different shapes into industrial education facilities.

Suggested layouts

The following suggested industrial education facility layouts are only a few of many designs being used today. Each school situation is different in program, number of offerings, and restrictions in design. Thus, no one layout is best. Different layouts must be studied to determine the one which fits a particular project. Some of the design layouts show a relationship of industrial education to other disciplines, relationship of industrial education laboratories to one another, or detailed layout for individual laboratories. A variety of shapes are shown to illustrate the alternatives available.

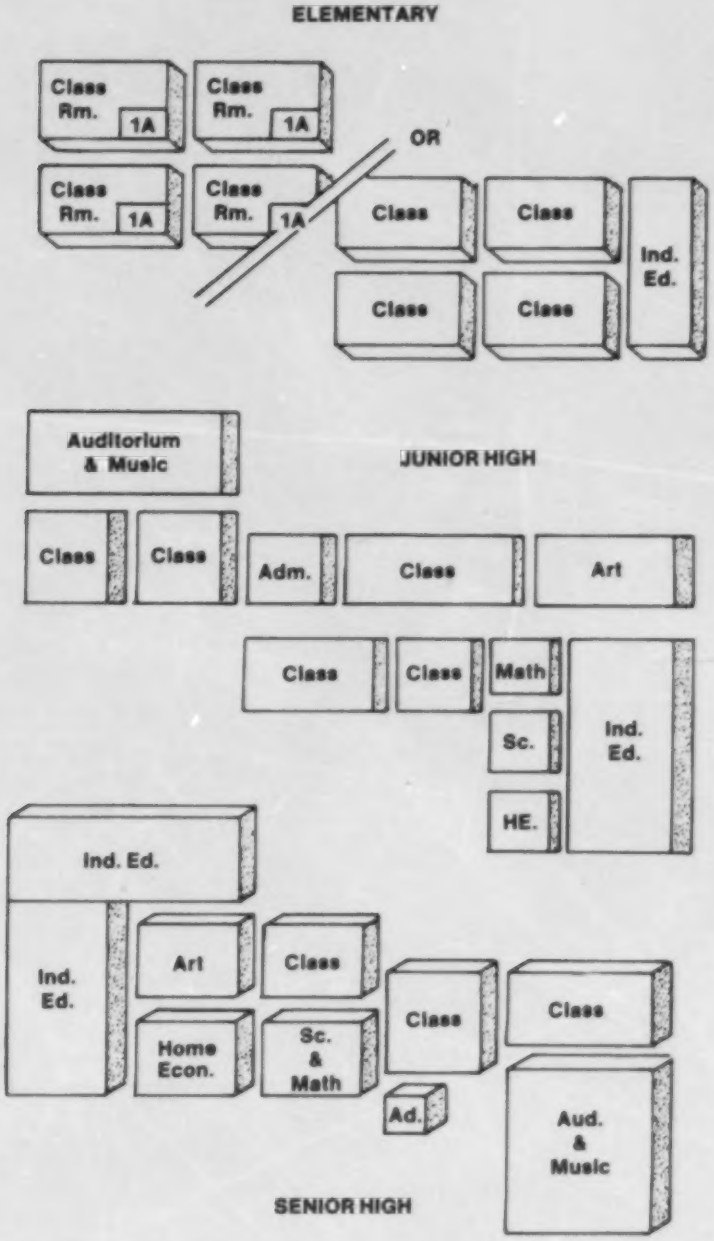


FIGURE 28

Location of industrial education in relation to other disciplines within the school.

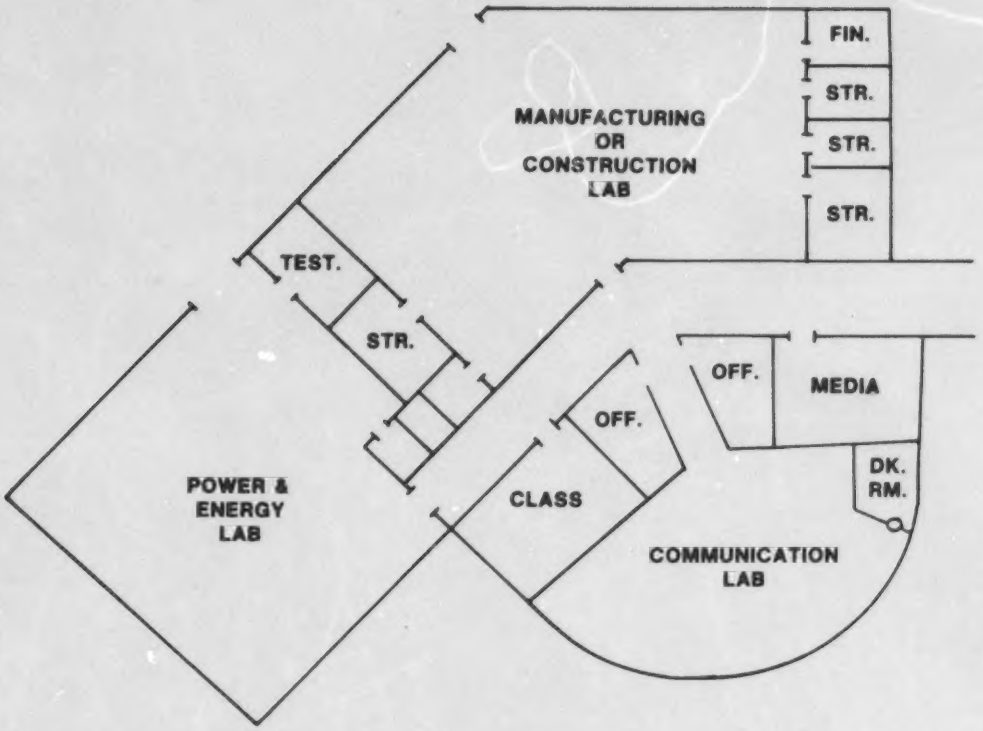


FIGURE 29

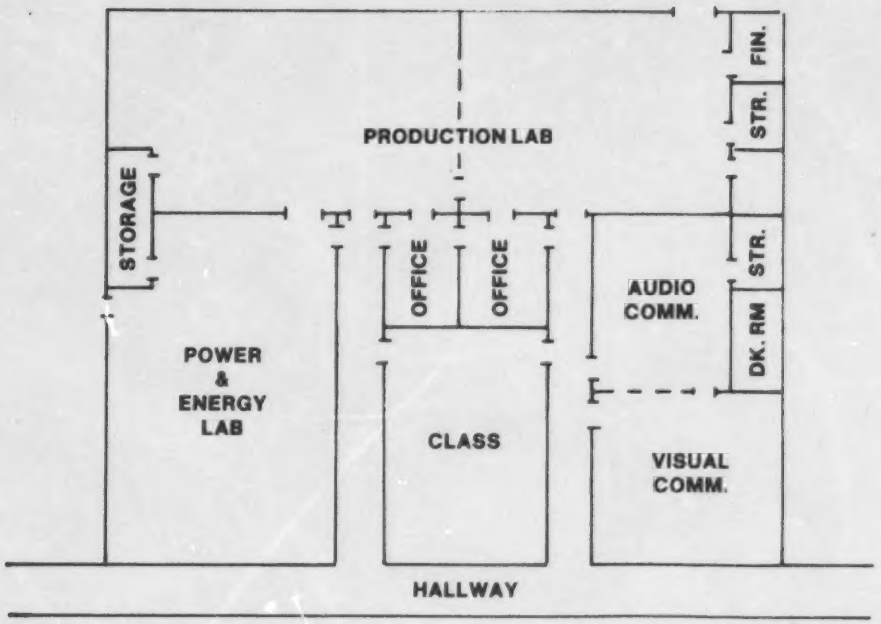


FIGURE 30

Industrial education department layout.

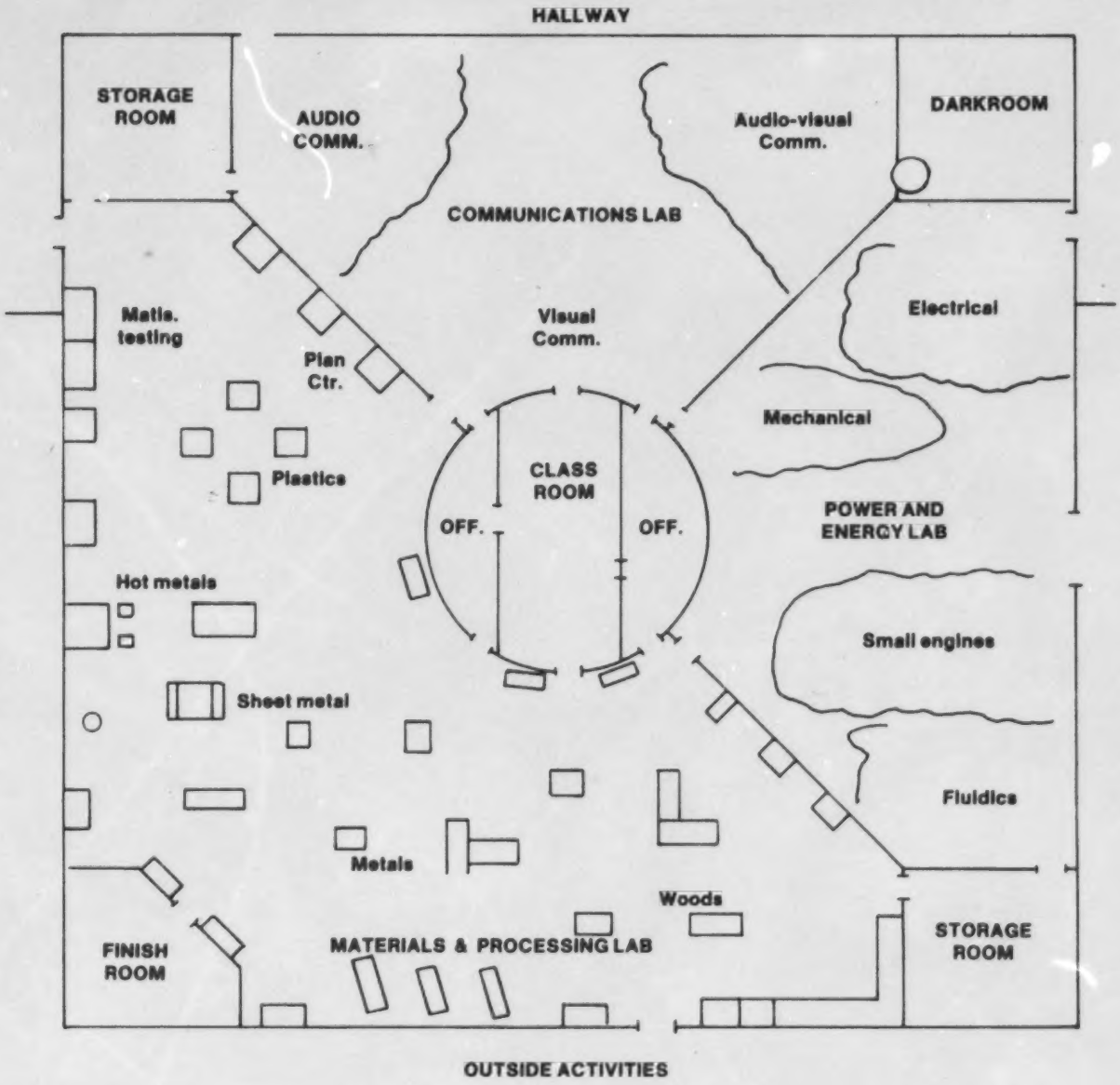


FIGURE 31

Industrial education department layout.

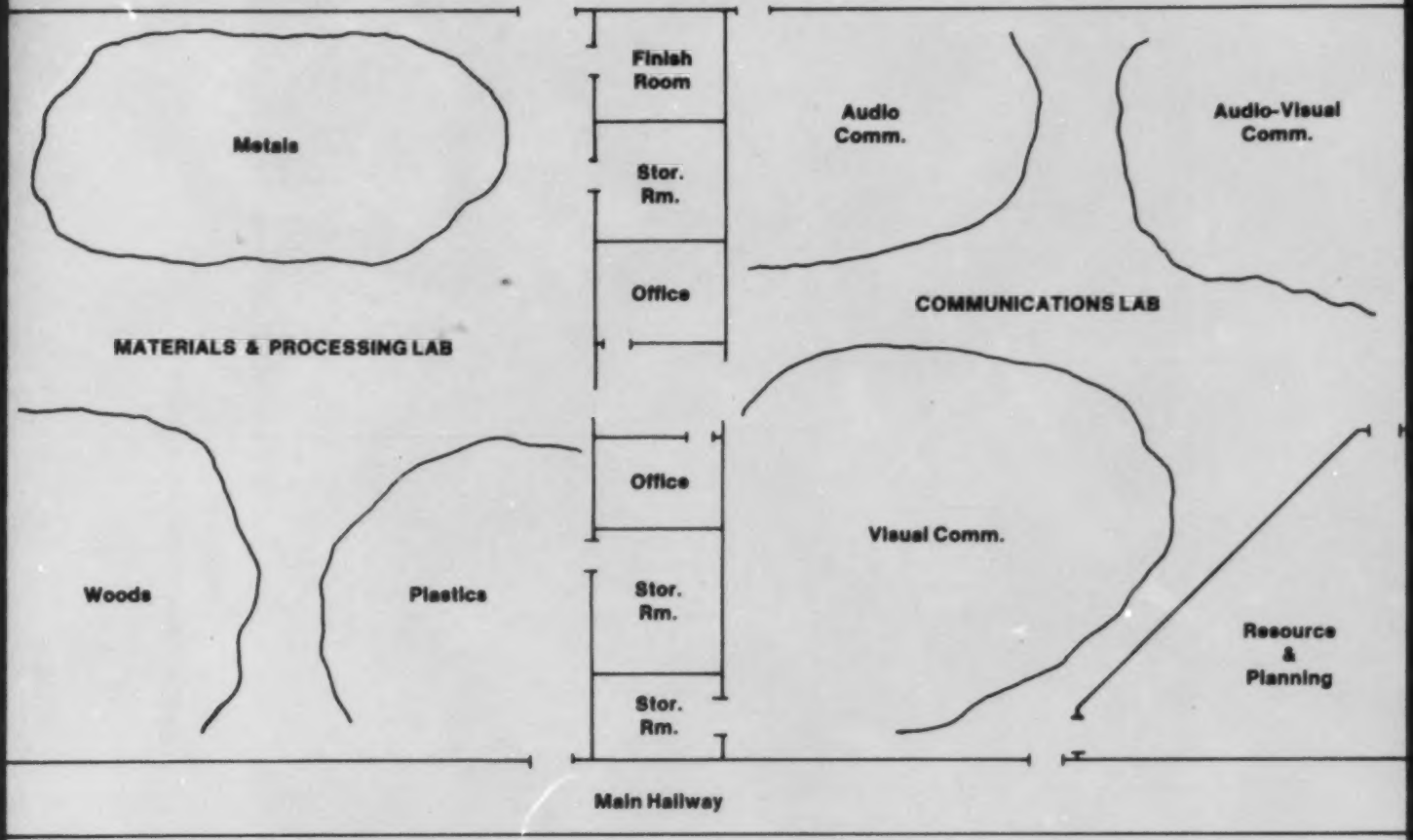


FIGURE 32

Junior high industrial education layout.

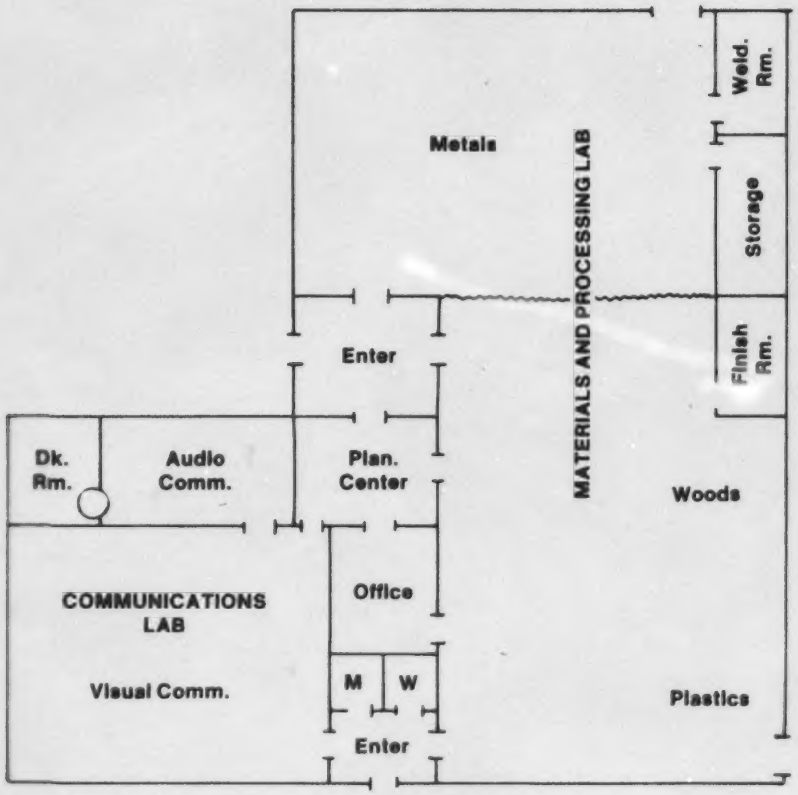


FIGURE 33
Industrial education department

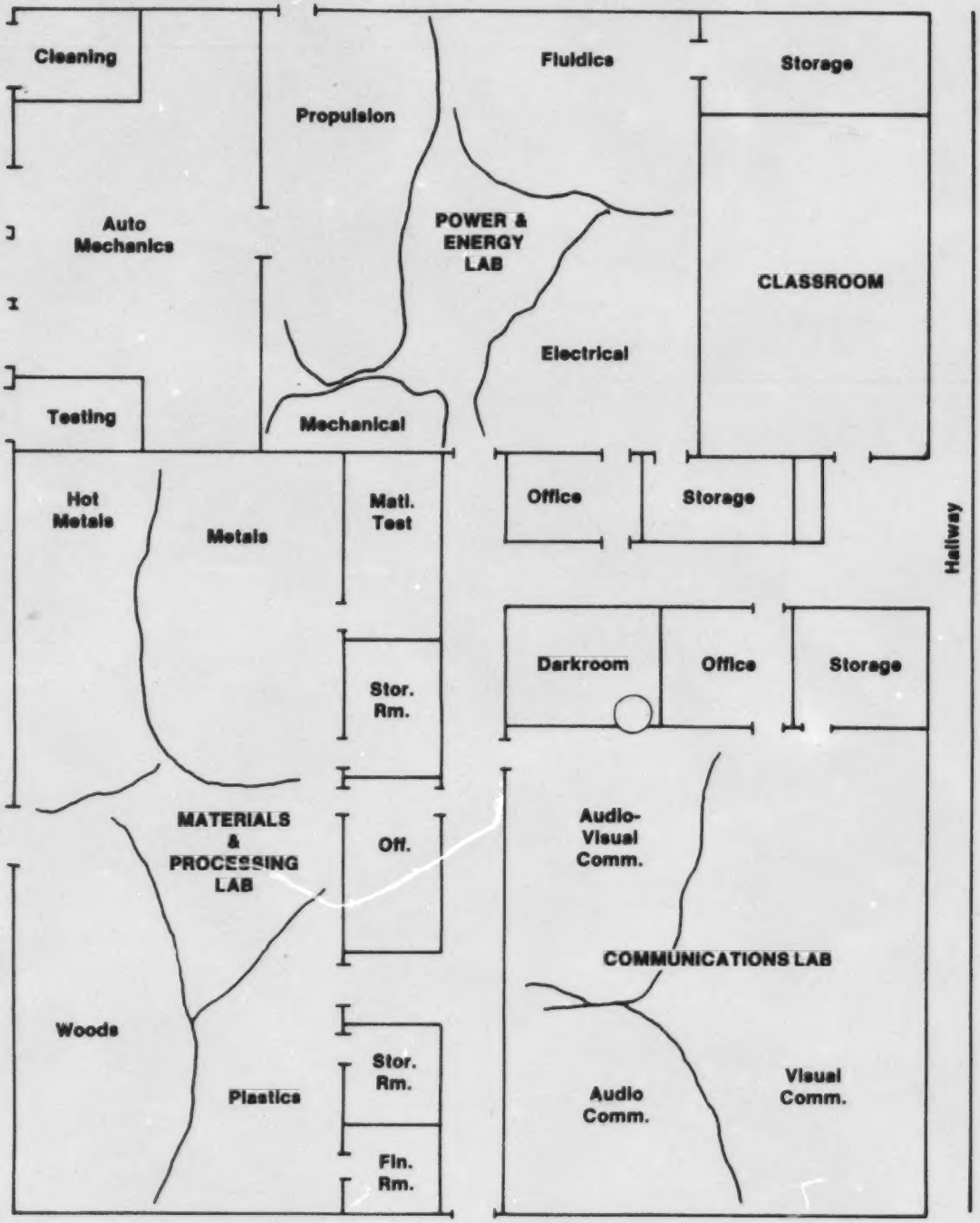


FIGURE 34

Senior high industrial education department.

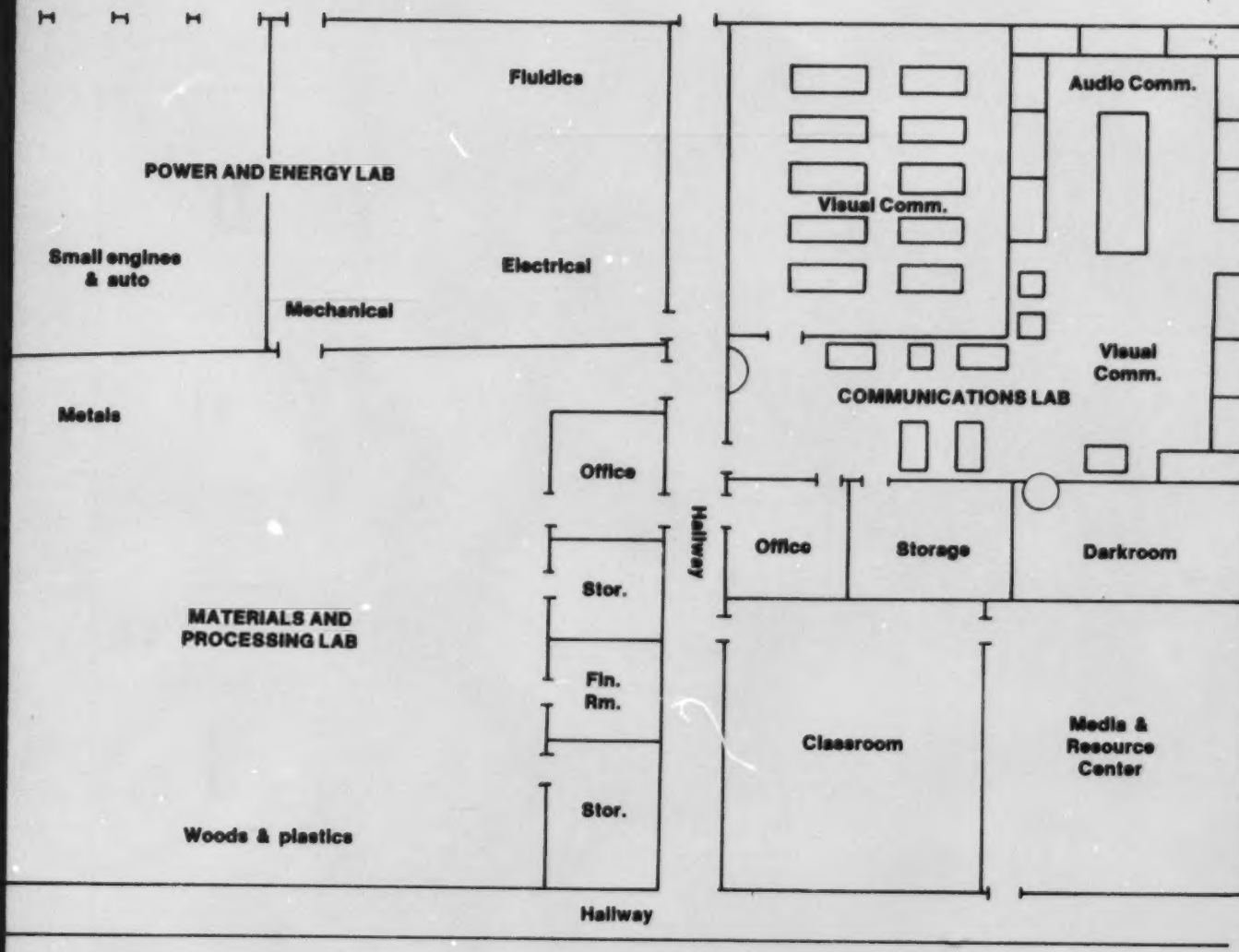


FIGURE 35
Senior high industrial education layout.

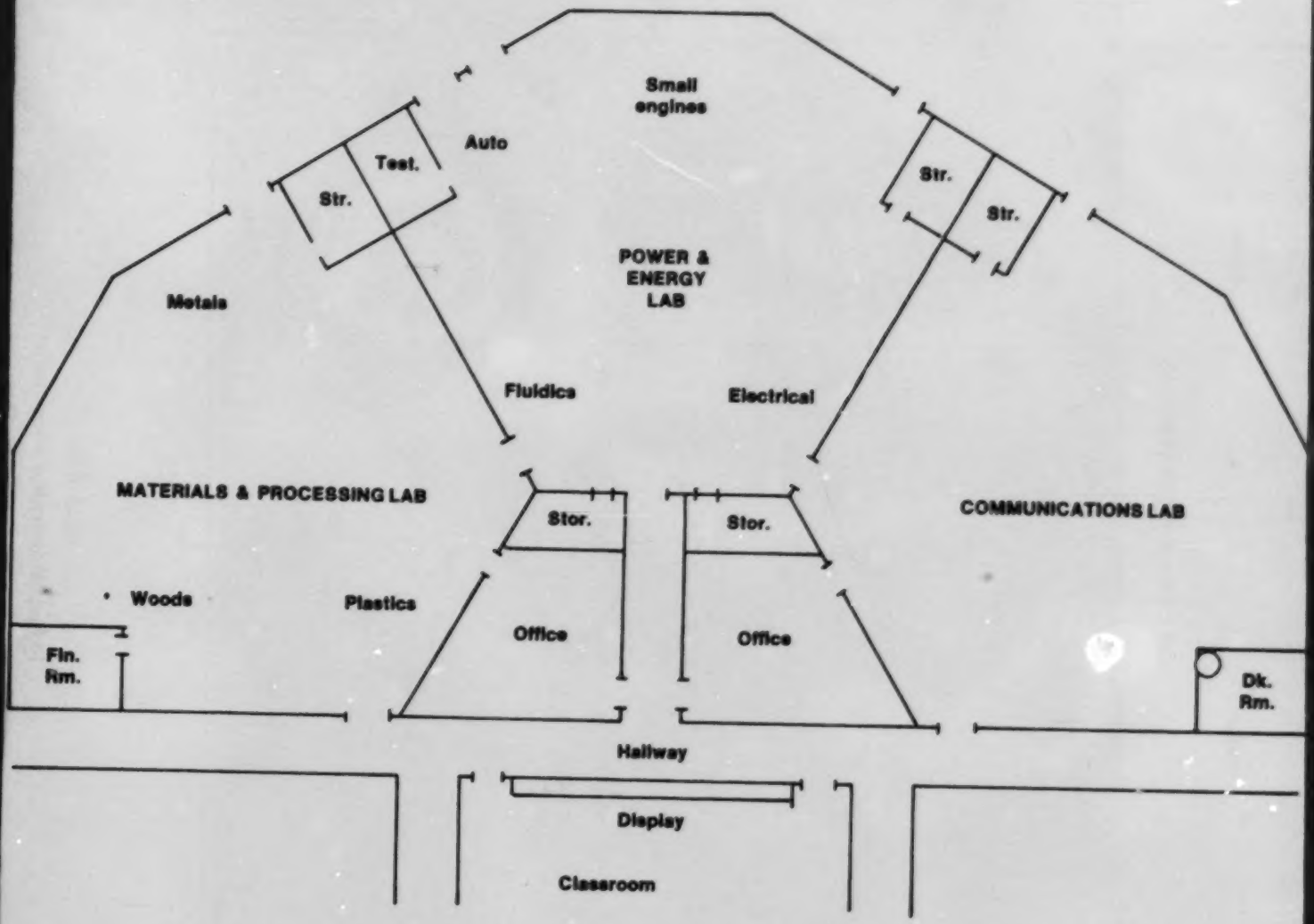


FIGURE 38

Senior high industrial education layout.

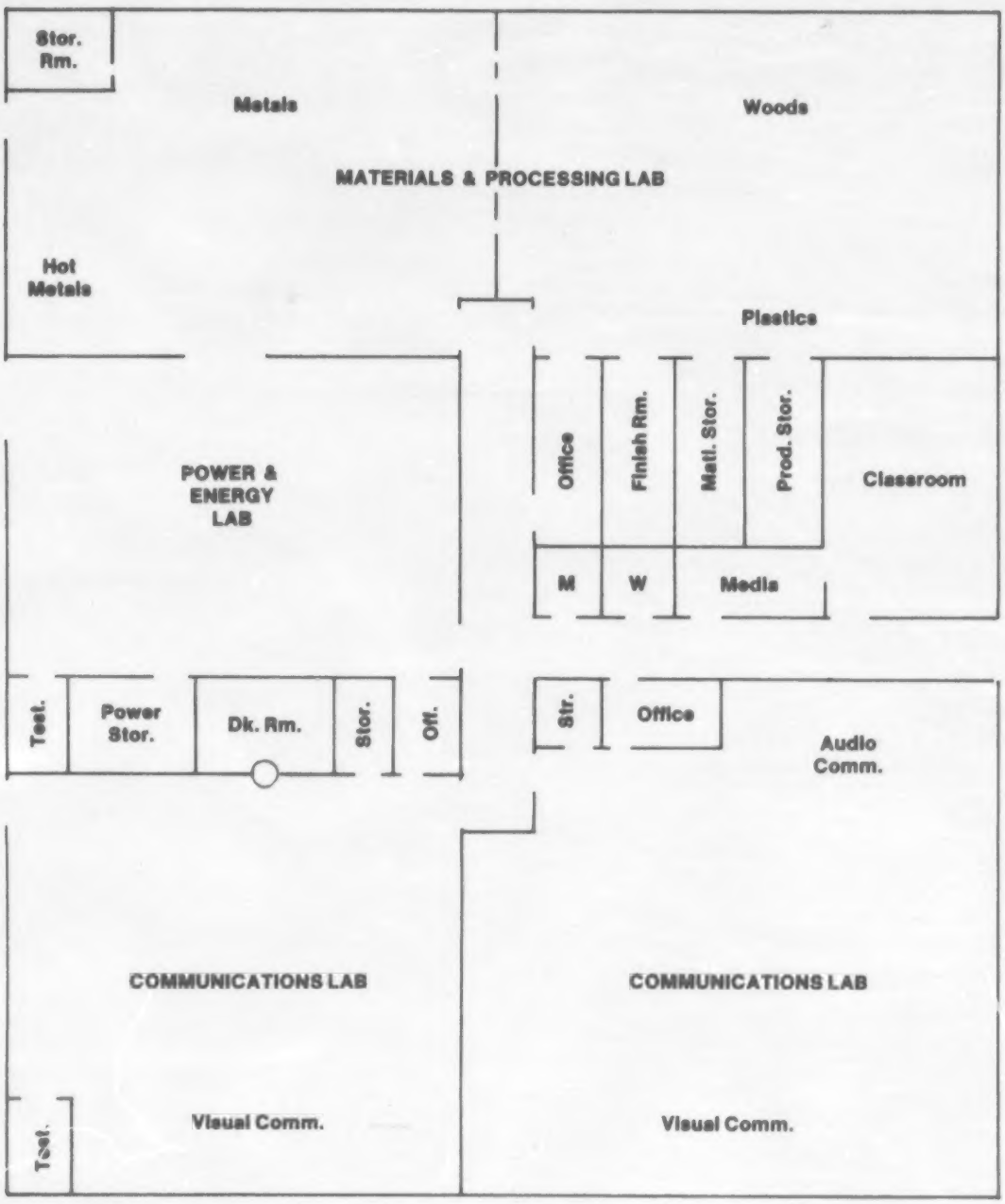


FIGURE 37
Industrial education department.

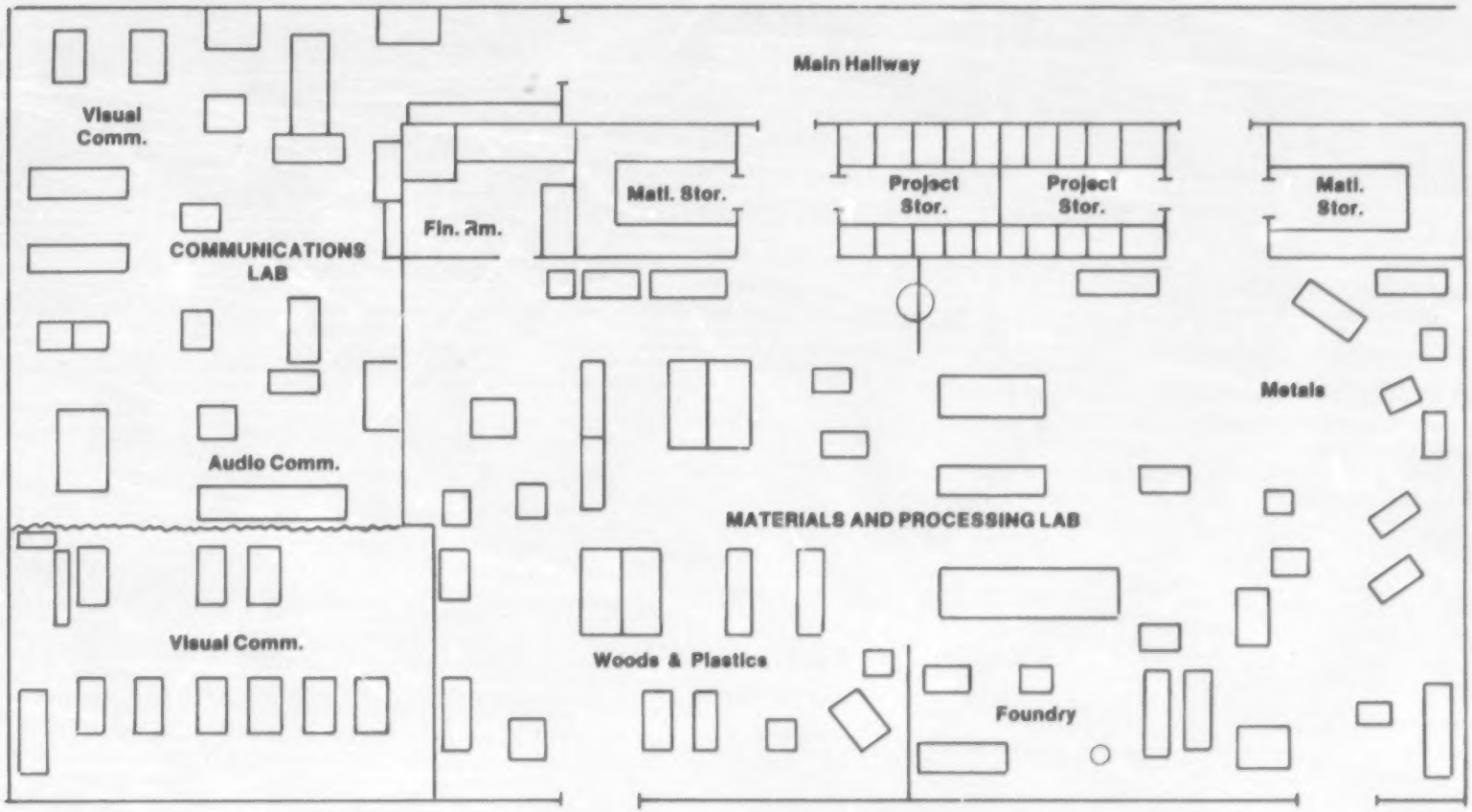


FIGURE 38

Junior high industrial education layout.

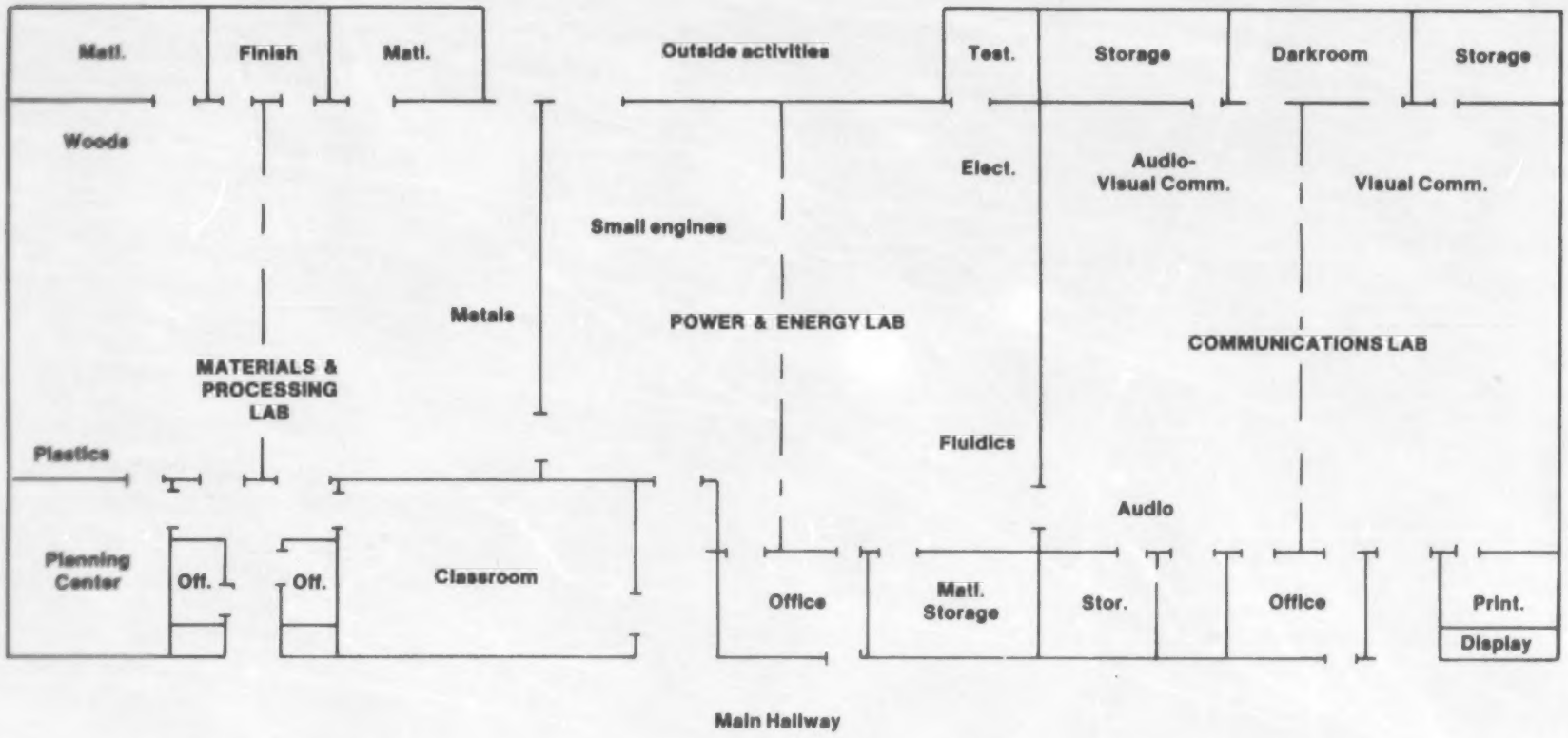


FIGURE 39

Industrial education laboratory layout.

CHAPTER XIII
OCCUPATIONAL SAFETY AND HEALTH ACT AS APPLIED TO INDUSTRIAL EDUCATION FACILITIES

Safety in the laboratory

Most industrial education teachers will admit that although the unsafe acts of students cause most school shop accidents, an effective accident prevention program must begin with safe machines, tools, procedures, and environments (16, p 45). A small number of accidents are, perhaps, chance happenings. However, nearly all are caused by identifiable unsafe acts or conditions and are, therefore, avoidable. Major causes of accidents in the industrial education shops include: (5, p 287).

1. Unfavorable environmental conditions, such as exhaust, lighting, etc.
2. Lack of (or improper) fire protection equipment.
3. Lack of sufficient space.
4. Inadequate electrical systems.
5. Insufficient or poor material storage.
6. Poor housecleaning in shops.
7. Insufficient equipment maintenance.
8. Lack of good safety instruction.
9. Enforcement of safety rules.
10. Unwise equipment selection.

Each of these causes can be prevented or offset by a good safety program, good laboratory planning and an equipment maintenance program.

Industrial education teachers planning a new laboratory or remodeling an old facility must constantly be aware of safety and health needs when undertaking the task of securing necessary equipment and specifying other conditions in the facility. They are not only concerned with machine and tool safety but also exhaust systems, ventilation, fire protection, electrical systems, personal safety equipment, and good laboratory organization. Every industrial education teacher has the responsibility to make a determined effort to minimize the seriousness and effects of accidents that could occur in his laboratory.

Although the Occupational Safety and Health Act of 1970 (OSHA) was passed to assure safe and healthful working conditions for every man and woman, its implication for educational institutions cannot be disregarded. Already, several states have established state plans regarding OSHA and its implementation.

Safety in industry is a matter of good training and education in safe working practices. Industrial education can provide the environment and experiences to teach students safer working habits as they study about industry in the laboratory.

The goal of the Wisconsin Occupational Safety and Health Plan is to produce a recognized reduction in the reported industrial injuries and illnesses occurring annually in Wisconsin. It is intended to work towards the provision of safe and healthful work environments through the combined use of voluntary compliance, educational activities and meaningful sanctions applied where required. It is the intent of the State of Wisconsin to adopt and enforce the Federal standards.

It is recommended that each school system have available a copy of the State Plan and the Federal Register on Occupational Safety and Health Standards. In some cases further investigation will be necessary to find specific standards such as those found in the State and National Electrical Codes and the National Fire Protection Codes as well as Building Codes. Other standards organizations referred to are found in each sub-section of the Federal Register.

Sub-sections of the federal register

There are many sections of the Federal Register that will have a direct effect on industrial education facilities. It would be impossible to include all items in this guide. However, there are priority items in the Federal Register to which attention can be brought. They are as follows:

1. Walking—Working Surfaces (Subpart D).
   - 1910.22—General requirements.
   - 1910.23—Guarding floor and wall openings.
   - 1910.25—Portable wood ladders.
   - 1910.26—Portable metal ladders.
   - 1910.30—Other working surfaces.
2. Means of Egress (Subpart E).
3. Environmental Control (Subpart G).
   - 1910.93—Air contaminants.
   - 1910.94—Ventilation.
   - 1910.95—Occupational noise exposure.
4. Hazardous Materials (Subpart H).
   - 1910.101—Compressed gases.
   - 1910.102—Acetylene.
   - 1910.104—Oxygen.
   - 1910.106—Flammable & combustible liquids.
   - 1910.107—Spray finishing.
5. Personal Protective Equipment (Subpart I).
6. General Environmental Controls (Subpart J).
   - 1910.141—Sanitation.
   - 1910.144—Safety color code.
   - 1910.145—Specifications for accident prevention signs and tags.
7. Medical and First Aid (Subpart K).
8. Fire Protection (Subpart L).
9. Compressed Gas & Compressed Air Equipment (Subpart M).
10. Materials Handling and Storage (Subpart N).
    - 1910.176—Handling materials—general.
    - 1910.177—Indoor general storage.
11. Machinery and Machine Guarding (Subpart O).
12. Hand and Portable Powered Tools (Subpart P).
13. Welding, Cutting and Brazing (Subpart Q).
14. Electrical (Subpart S).

The following are some excerpts from the Federal Register on rules and regulations directly related to industrial education facilities.

1910.36 General Requirements.

(8) Every building or structure, section or area thereof, of such size, occupancy, and arrangement that the reasonable safety of numbers of occupants may be endangered by the blocking of any single means of egress due to fire or smoke, shall have at least two means of egress remote from each other, so arranged as to minimize any possibility that both may be blocked by any one fire or other emergency conditions. (11, p 22130).

1910.95 Occupational Noise Exposure.

Loss of hearing occurs as result of the cumulative effect of exposure to sound above a maximum intensity and over a maximum duration in a given period of time. For the purpose of this standard, the basic permissible intensity is 90 decibels, when measured on the "A" scale of a standard sound level meter set at "slow" response, for a duration of 8 hours out of a day. If the variations in noise level involve maximum at intervals of one second or less, it is to be considered continuous. Table I indicates the duration of exposure to higher sound intensities which will result in no more damage to hearing than produced by 8 hours at 90 decibels. Employees must not be exposed to steady sound levels above 115 decibels, regardless of the duration. (11, p 22157).

Table I

Permissible Noise Exposures

Duration per Day, Hours	Sound level in Decibels, slow response
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼ or less	115

1910.94 Ventilating.

Hoods connected to exhaust systems shall be used, and such hoods shall be designed, located, and placed so that the dust or dirt particles shall fall or be projected into the hoods in the direction of the air flow. Exhaust ventilating systems for removing contaminated air from a space, comprises two or more of the following elements (a) enclosure or hood, (b) duct work, (c) dust collector, (d) exhauster, and (e) discharge stack. (11, p 22144).

1910.101 Compressed Gases.

All compressed gas cylinders shall be stored and transported in an upright position and lashed or chained so they cannot topple over. Caps shall be kept on all cylinders when not in use. All compressed gas cylinders should be shut-off at the cylinder valve and not at the regulator. (11, p 22163).

1910.106 Flammable and Combustible Liquids.

Flammable or combustible liquids shall be stored in tanks or closed containers. Fire resistance storage cabinets must be used and marked in conspicuous lettering, "Flammable—Keep Fire Away". A maximum capacity of not more than 60 gallons of flammable or 120 gallons of combustible liquids may be stored in a storage cabinet. The quantity of liquid that may be located outside of an inside storage room or storage cabinet in a building shall not exceed 25 gallons of Class IA (includes those having flash points below 73 degrees Fahrenheit and having a boiling point below 100 degrees Fahrenheit). At least one portable fire extinguisher, of proper type, shall be located outside of, but not more than 10 feet from, the door opening into any room used for storage. (11, p 22169).

1910.107 Spray Finishing.

All spraying areas shall be provided with mechanical ventilation adequate to remove flammable vapors, mists, or powders to a safe location and to confine and control combustible residues so that life or property is not endangered. Spray booths shall be constructed according to correct specifications. (11, p 22187).

1910.132 Personal Protective Equipment—General Requirements.

Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact. (11, p 22231).

1910.141 Sanitation.

Housekeeping—all places of employment, passageways, storerooms, and service rooms shall be kept clean and orderly and in a sanitary condition. (11, p 22234).

1910.144 Safety Color Code.

Red—identification of fire protection equipment.
Orange—designating dangerous parts of machines.
Yellow—designating caution areas.
Green—designating safety and first aid equipment.
Blue—designating caution against use, moving, starting of equipment.
Purple—designating radiation.
Black, white or combinations thereof—designating traffic and housekeeping markings. (11, p 22238).

1910.145 Accident Prevention Signs and Tags.

Danger signs — used only where an immediate hazard exists. Color—red, black & white.

Caution signs — warn against potential hazards or caution against unsafe practices. Color — yellow and black.

Safety instruction signs — need for general instructions and suggestions relative to safety measures.

"Do not start," danger & caution tags should be used as temporary means of warning. (11, p 22239).

1910.151 Medical Services & First Aid.

The employer shall ensure the ready availability of medical personnel for advice and consultation on matters of health. In the absence of an infirmary, clinic, or hospital in near proximity to the workplace which is used for the treatment of all injured employees, a person or persons shall be adequately trained to render first aid. First aid supplies approved by the consulting physician shall be readily available. (11, p 22242).

1910.157 Portable Fire Extinguishers.

A fire extinguisher, rated not less than 2A, shall be provided, for each 3000 square feet of ordinary hazard occupancy, or major fraction thereof. Travel distance from any point of the protected area to the nearest fire extinguisher shall not exceed 75 feet. Portable fire extinguishers shall be inspected periodically and maintained in accordance with maintenance and use of Portable Fire Extinguishers, NFPA No. 10A-1970. All fire extinguishers shall be mounted properly in easy to get locations and properly marked. (11, p 22243).

1910.212 General Requirements for all Machines.

One or more methods of machine guarding shall be provided to protect the operator and other employees in the machine areas from hazards such as those created by point of operation, in-going nip points, rotating parts, flying chips, and sparks. Guards shall be affixed to the machine where possible and secured elsewhere if for any reason attachment to the machine is not possible. Point of operation is the area on a machine where work is actually performed upon the material being processed. This area shall be guarded. Anchoring fixed machinery. Machines designed for a fixed location shall be securely anchored to prevent walking or moving. (11, p 22273).

1910.213 Woodworking Machinery Requirements.

All belts, pulleys, gears, shafts, and moving parts shall be guarded in accordance with specific requirements of Section 1910.219.

Combs (featherboards) or suitable jigs shall be provided at the work-place for use when a standard guard cannot be used, as in dadoing, grooving, jointing, molding, and rabbeting.

A mechanical or electrical power control shall be provided for each machine to make it possible for the operator to cut off power from each machine without leaving his position at the point of operation.

On applications where injury to the operator might result if motors were to restart after power failures, provisions shall be made to prevent machines from automatically restarting upon restoration of power.

Power controls and operating controls shall be located within easy reach of the operator while he is at his regular work location making it unnecessary for him to reach over the cutter to make adjustments.

Hand-fed ripsaws.

1) each circular hand-fed ripsaw shall be guarded by a hood which shall completely enclose that portion of the saw above the table and that portion of the saw above the material being cut. The hood and mounting shall be arranged so that the hood will automatically adjust itself to the thickness of and remain in contact with the material being cut but it shall not offer any considerable resistance to insertion of material to saw or to passage of the material being sawed. The hood shall be made of adequate strength to resist blows and strains incidental to reasonable operation adjusting and handling, and shall be so designed as to protect the operator from flying splinters and broken saw teeth. It shall be made of material that is soft enough so that it will be unlikely to cause tooth breakage. The material should not shatter when broken, should be non-explosive, and should be no more flammable than wood. The hood shall be so mounted as to insure that its operation will be positive, reliable, and in true alignment with the saw; and the mounting shall be adequate in strength to resist any reasonable side thrust or other force tending to throw it out of line.

2) Each hand-fed circular ripsaw shall be furnished with a spreader to prevent material from squeezing the saw or being thrown back on the operator. The spreader shall be made of hard tempered steel, or its equivalent, and shall be thinner than the saw kerf. It shall be of sufficient width to provide adequate stiffness or rigidity to resist any reasonable side thrust or blow tending to bend or throw it out of position. The spreader shall be attached so that it will remain in true alignment with the saw, even when either the saw or table is tilted, and should be placed so that there is not more than ½ inch space between the spreader and the back of the saw when the largest saw is mounted in the machine.

3) Each hand-fed circular ripsaw shall be provided with non-kick back fingers or dogs so located as to oppose the thrust or tendency of the saw to pick up the material or to throw it back toward the operator. They shall be designed to provide adequate holding power for all the thickness of material being cut. (11, p 2274).

Jointers.

Each hand-fed planer or jointer with horizontal head shall be equipped with a cylindrical cutting head, the knife projection

of which shall not exceed one-eighth inch beyond the cylindrical body of the head.

The opening in the table shall be kept as small as possible. The clearance between the edge of the rear table and the cutter head shall be not more than one-eighth inch. The table throat opening shall be not more than 2 ½ inches when tables are set or aligned with each other for zero cut.

Each hand-fed jointer with a horizontal cutting head shall have an automatic guard which will cover all the section of the head on the working side of the fence or gage. The guard shall effectively keep the operator's hand from coming in contact with the revolving knives. The guard shall automatically adjust itself to cover the unused portion of the head and shall remain in contact with the material at all times.

Each hand-fed jointer with horizontal cutting head shall have a guard which will cover the section of the head back of the gage or fence.

Each wood jointer with vertical head shall have either an exhaust hood or other guard so arranged as to enclose completely the revolving head, except for a slot of such width as may be necessary and convenient for the application of the material to be jointed. (11, p 22275).

Lathes.

Lathes used for turning long pieces of wood stock held only between the two centers shall be equipped with long curved guards extending over the tops of the lathes in order to prevent the work pieces from being thrown out of the machine if they should become loose. (11, p 22276).

Sanding Machines.

Each disc sanding machine shall have the exhaust hood, or other guard if no exhaust system is required, so arranged as to enclose the revolving disc, except for that portion of the disc above the table, if a table is used, which may be necessary for the application of the material to be finished.

Belt sanding machines shall be provided with guards at each nip point where the sanding belt runs on to a pulley. These guards shall effectively prevent the hands or fingers of the operator from coming in contact with the nip points. The unused run of the sanding belt shall be guarded against accidental contact. (11, p 22276).

Miscellaneous.

All knives and cutting heads of woodworking machines shall be kept sharp, properly adjusted, and firmly secured. Where two or more knives are used in one head they shall be properly balanced.

Push sticks or push blocks shall be provided at the work-place in the several sizes and types suitable for the work. (11, p 22276).

1910.215 Abrasive Wheel Machinery.

Abrasive wheels shall be used only on machines provided with safety guards fitting specifications. The safety guard shall cover the spindle end, nut and flange projections. The safety guard shall be mounted so as to maintain proper alignment with the wheel, and the strength of the fastenings shall exceed the strength of the guard.

On off-hand grinding machines, work rests shall be used to support the work. They shall be of rigid construction and designed to be adjustable to compensate for wheel wear. Work rests shall be kept adjusted closely to the wheel with a maximum opening of one-eighth inch to prevent the work from being jammed between the wheel and rest, which may cause wheel breakage. The work rest shall be securely clamped after each adjustment. The adjustment shall not be made with the wheel in motion. (11, p 22278).

1910.242 Hand and Portable Powered Tools.

Each employer shall be responsible for the safe condition of tools and equipment used by employees, including tools and equipment which may be furnished by employees.

Compressed air shall not be used for cleaning purposes except where reduced to less than 30 psi and then only with effective chip guarding and personal protective equipment. (11, p 22295).

1910.309 National Electrical Code.

Articles and sections of the National Electrical Code, NFPA 70-1971; ANSI-Ci-1971 (Rev. of 1968) shall apply to all electrical installations and utilization of equipment. (11, p 22342).

Safety checklist

The following checklist is designed merely as an aid to discovering areas in the industrial education laboratories where safety hazards may exist. It does not attempt to cover everything included in the Occupational Safety and Health Act. The person using this checklist should be familiar with the rules and regulations found in the Federal Register. It is recommended that a safety consultant be made available for any questions you may have in regard to interpretation of the regulations.

SAFETY CHECKLIST FOR INDUSTRIAL EDUCATION

ITEM	APPEARS OKAY	NEEDS ACTION	N/A	COMMENTS
A. Walking-Working Surfaces.				
1. Housekeeping.				
a. floors clean				
b. aisles clear				
c. floors dry				
d. operator non-skid				
e. aisles marked				
f. stairways clear				
2. Guarding floor & wall openings.				
a. stairway railings				
b. floor holes covered				
c. floor wells guarded				
d. floors fire proof in hot metals area				
3. Ladders.				
a. properly braced				
b. no loose or broken steps				
c. safety feet provided				
d. proper material				
B. Means of Egress and Exit.				
1. Way of exit access clear				
2. Exit clear				
3. Beyond exit clear				
4. Exits properly marked				
5. More than one exit				
6. Doors swing outward				
C. Environmental Control.				
1. Dust collector.				
a. adequate cfm				
b. all machines connected, where applicable				
c. floor sweep available				
d. ducts correct size				
e. on/off switch in lab				
f. clean out trap provided				
g. hopper sufficient				
2. Fume control.				
a. ducts over hot metals				
b. adequate cfm				
c. size adequate				
d. welding booths ducted				
e. adequate size for (d)				
f. adequate cfm for (d)				
g. darkroom ducted				
h. spray booth ducted				
i. finishing room ducted				
j. diazo machine ducted				
3. Noise level.				
a. safe noise level				
b. baffling provided in extremely noisy areas				
D. Hazardous Materials.				
1. Acetylene/Oxygen.				
a. containers marked				
b. cylinders tied down				
c. cylinders stored upright				
d. caps on unused cylinders				
e. valves closed (not in use)				
f. safe distance from welding bench				
g. on/off wrenches in position				
h. all fittings tight				
2. Flammable & combustible liquids.				
a. kept in locked storage				
b. metal storage cabinets				
c. proper ventilation				

ITEM	APPEARS OKAY	NEEDS ACTION	N/A	COMMENTS
d. 25 gal. limit outside storage cabinet				
e. fire extinguisher within 10 ft. of storage room				
f. properly marked				
g. metal containers used for storage of liquids				
E. Personal Protective Equipment				
1. Safety glasses available				
2. Face shields provided in hot metals area and on lathes				
3. Welding goggles provided				
4. Face masks for spraying				
5. Hard hats provided where applicable				
6. Rubber protective equipment in electrical area				
7. Hot metal clothing				
8. Fire blanket provided				
9. Hearing protection provided				
F. Sanitation.				
1. Waste disposal available				
2. Restrooms nearby				
3. Drinking fountain nearby				
4. Wash sinks available				
5. Cleaning sink available				
G. Safety Color Code & Markings.				
1. Color codes used				
2. Accident prevention signs				
a. danger signs				
b. caution signs				
c. safety instruction signs				
3. Accident prevention tags				
a. out-of-order tags				
b. do not start tags				
c. danger tags				
d. caution tags				
H. First Aid.				
1. First aid cabinet supplied				
2. First aid cabinet marked				
I. Fire Protection.				
1. Fire extinguishers				
a. properly marked				
b. hanging properly				
c. easy access				
d. inspected & marked				
e. proper types				
f. located within 75 feet of anywhere in shop				
J. Compressed Air.				
1. Valves off when not in use				
2. Air pressure gauges at all locations where used				
3. Air outlets not in use properly capped				
4. Moisture drains in lines				
K. Machinery.				
1. Guards				
a. affixed to all machines				
b. working properly				
c. belts & pulleys guarded				
d. adjusted properly				
2. Fixed machinery anchored				
3. Blades kept sharp				
4. Push sticks available				
5. Grinder table adjusted ⅛" from wheel				
6. Color coded				
7. Operator zone marked				
8. Machines maintained				
L. Hand & Portable Powered Tools.				
1. Properly maintained				
2. Portable powered tools properly guarded				
3. Portable powered tools properly grounded				

ITEM	APPEARS OKAY	NEEDS ACTION	N/A	COMMENTS
M. Electrical.				
1. Magnetic switches on all machines.....				
2. All machines properly wired.....				
3. Proper conduit used for all wiring from bus-duct.....				
4. Panic buttons accessible.....				
5. Proper grounding on all electrical wiring.....				
6. Adequate amperage for operating needs.....				
7. Main switch box in lab.....				
8. All machine switches easily reached by operator.....				
N. Miscellaneous Comments.				

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APPENDIX

APPENDIX A
EDUCATIONAL SPECIFICATIONS

I. Philosophy.

- A. State the philosophy and goals of industrial education.
- B. State the objectives of the industrial education program.

II. Instructional Program.

- A. Develop the scope and sequence of courses to be offered in the industrial education program according to grade level.
- B. List the courses by title and give a brief description of their content.
- C. Give a short description of the types of teacher and student activities to be implemented in the facility.

III. Space Needs.

- A. Estimate of school enrollment.
- B. Estimate of industrial education enrollment.
- C. Class sizes.
- D. Number of class sections necessary.
- E. Determine square footage per laboratory and auxiliary areas.

IV. Equipment.

- A. List, by laboratory, where equipment will be located.
- B. Give quantity, name, size, floor space (including operator space), and utility requirements.
- C. Divide list into fixed and movable categories for each laboratory.

V. Auxiliary Space.

- A. List each auxiliary space requirement.
- B. List equipment for each auxiliary area.

VI. Environmental Considerations.

- A. Specify by laboratory and auxiliary space.
- B. Specify visual, auditory, air, utilities, and structural requirements desired.

VII. Space Relationships.

- A. Block or bubble diagrams showing relationship of industrial education area to other areas of the school.
- B. Diagrams relating areas within industrial education to each other.
- C. Diagrams of each laboratory relating auxiliary areas.

VIII. Equipment Location.

- A. Layout of each laboratory and auxiliary area showing the placement of each piece of equipment.

APPENDIX B
COLOR CODES

Pittsburgh Color Dynamics.

A. Machines, stands, bases, other equipment.

1. Main body—vista green.
2. Electrical switches—focal orange.
3. Focal areas (e.g. the table insert on saw).
   a. Woodworking machines—focal orange.
   b. Metalworking machines—focal ivory.
4. Handwheels (except rims) —focal beige.
5. Levers (except handles) —focal beige.
6. Dangerous projections (e.g. a flywheel) —focal yellow striped with focal black.

B. Walls, partitions, columns, trim—medium to light green.

C. Doors—natural wood finish or vista green.

D. Ceilings—white, off-white, cream, ivory, or very light green.

E. Floors—natural wood finish or medium gray.

F. Color coding for safety.

1. Watch out—focal yellow striped with focal black. Warns against falling, stumbling, and projecting hazards. Four-inch focal yellow stripes on floors mark traffic lanes and danger areas around machines.
2. On guard—focal orange. Warns against dangerous parts and areas of equipment. Included are electrical switchboxes, machine guards, the insides of fuse box and circuit breaker box doors, and the areas around crushing and cutting edges.
3. Fire protection—red. Marks the location of fire fighting equipment and identifies the individual pieces such as fire extinguishers.
4. Out-of-service—blue. Blue disks are hung on pieces of equipment that are not to be used. "Out-of-order" is lettered in focal white on the focal blue background.
5. First aid—green. Marks the location of first aid supplies. A white cross on a green background further identifies a first aid cabinet. Entrances to first aid stations are identified by white crosses bordered with green.
6. Housekeeping facilities—white. Painted areas of floors indicate locations of waste receptacles. Temporary floor storage spaces are outlined by four-inch white stripes.
7. Pipe line identification.
   a. Fire protection materials (e.g. sprinklers) —red.
   b. Dangerous materials (e.g. acids, gases) —yellow or orange.
   c. Safe materials (e.g. drinking water, compressed air) —green, light gray, white, dark gray, or black.
   d. Protective materials (e.g. gases or liquids used as antidotes to dangerous materials) —blue.
   e. Extra-valuable materials—purple.

Note: The pipe should not be painted along its entire length but at intervals, the rest of the pipe should be painted the color of the surface to which it is adjacent.

DuPont Color Conditioning.

A. Machines, stands, bases, other equipment.

1. Main body—horizon gray.
2. Electrical switchboxes—blue.
3. Focal areas (e.g. levers, centers of handwheels, machinery guards, areas around points of operation) —spotlight buff.
4. Dangerous projections (e.g. flywheel) —yellow with black.
5. Alert area (e.g. areas around parts that can cut or crush and the insides of machinery part covers) —orange.

B. Walls, partitions, columns.

1. Lower third—medium gray or medium green.
2. Upper two-thirds—light green.

C. Doors, trim—natural wood finish, medium gray or medium green.

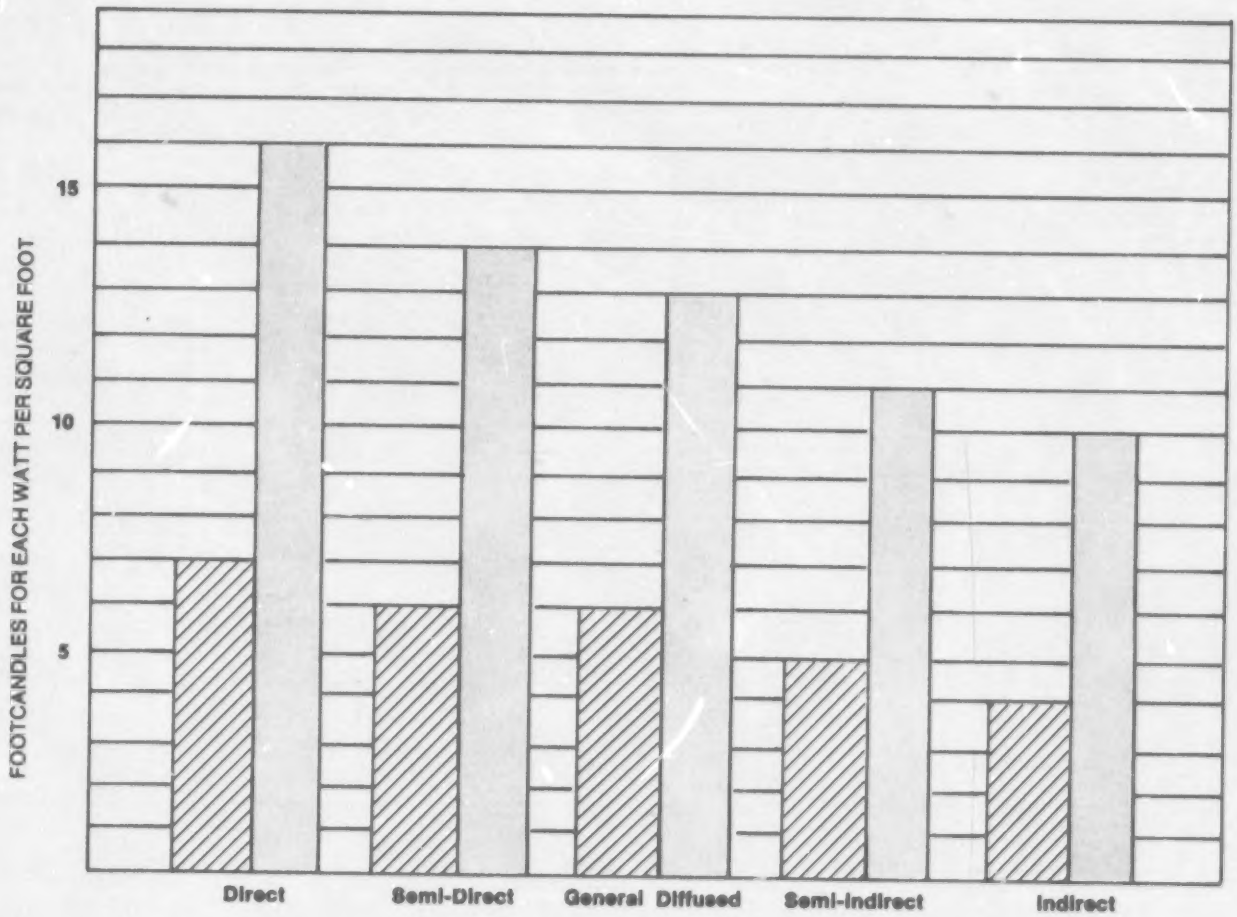
D. Ceilings—white or ivory.

E. Floors—natural wood finish or medium gray.

F. Color coding for safety.

The DuPont Color Conditioning and Pittsburgh Color Dynamics safety codes are the same with the exception of the color specified for electrical switchboxes. DuPont code recommends blue, and the Pittsburgh code specifies focal orange.

APPENDIX C
LIGHTING ESTIMATE



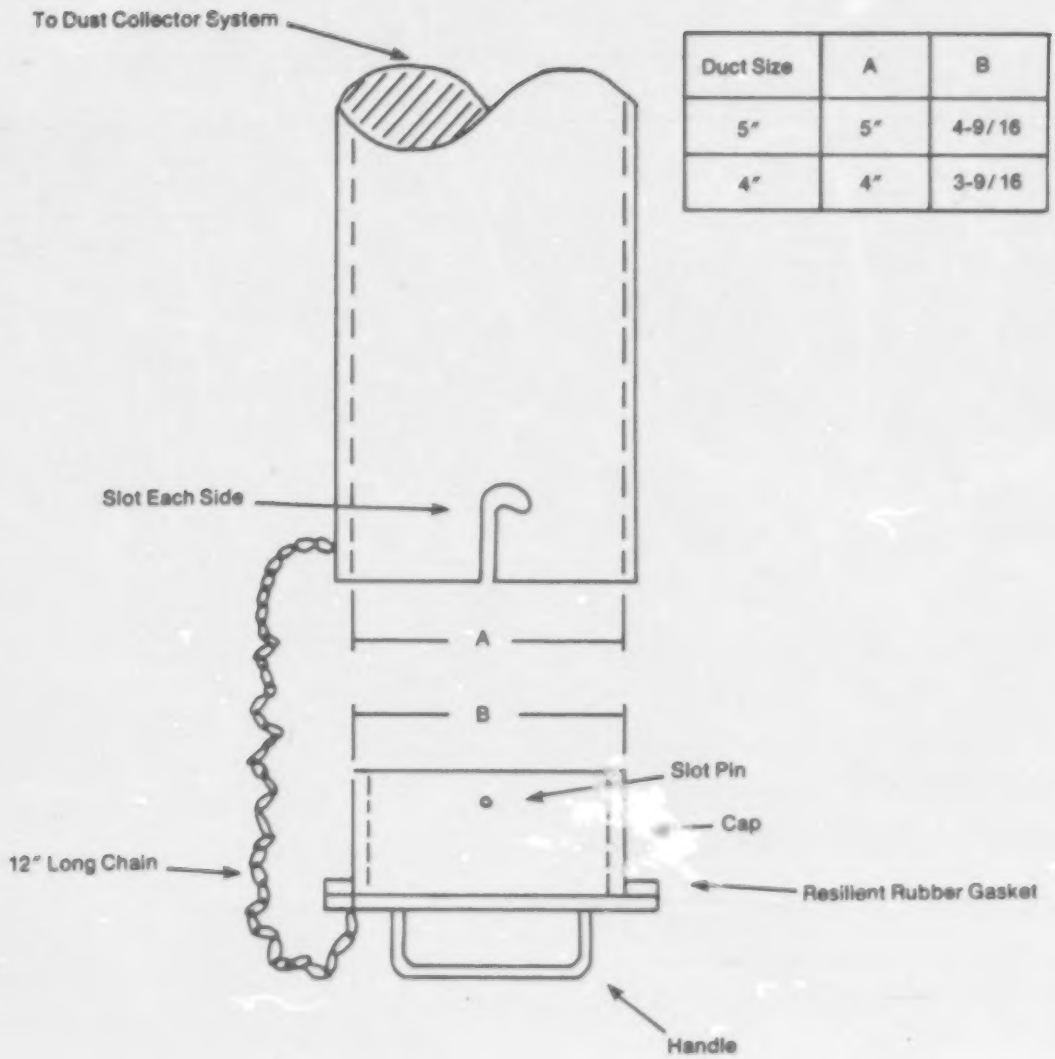
Formulas are available from lighting consultants to determine number of light fixtures and their wattages necessary for building spaces.

APPENDIX D

Recommended minimum levels of general illumination for industrial education areas as recommended by the Illuminating Engineering Society.

Work Area	Footcandles at 30 Inches off Floor
Communications	
Visual communications area	150
Audio communications area	100
Processes and Materials	150
Power and Energy	150
Classroom area	150
Office area	150
Finishing room	100
Clean-up area	30
Chalkboard area	150
Materials storage	30
Equipment storage	50
Project storage	50
Media resource center	150
Materials or equipment testing area	150

APPENDIX E
BRANCH DUCT EXHAUST CAP



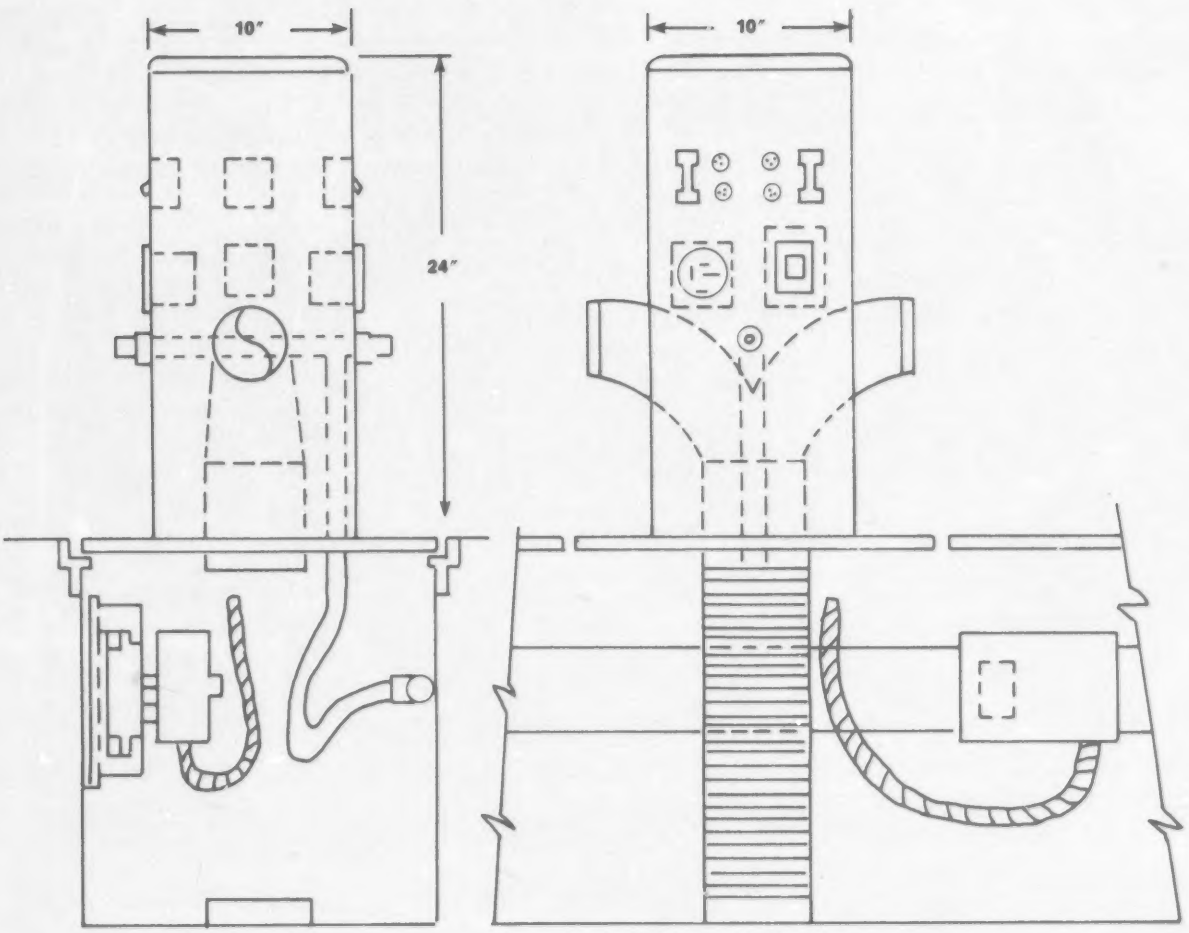
Duct Size	A	B
5"	5"	4-9/16
4"	4"	3-9/16

To connect to machine the cap is removed and a flexible exhaust hose is connected to exhaust duct. When cap is in position the resilient rubber gasket aids in reducing the sound of air moving through the system.

APPENDIX F

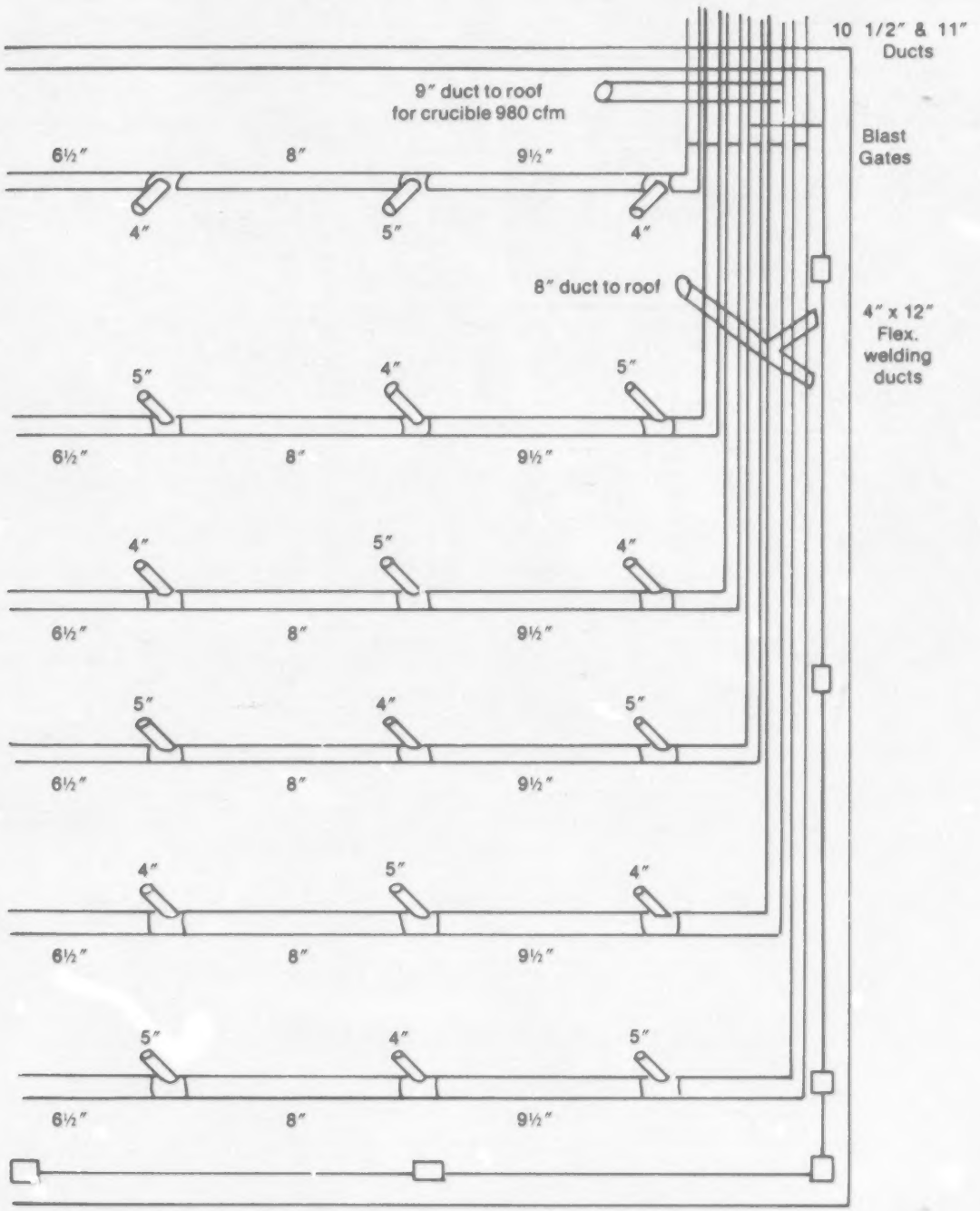
UTILITY POST DESIGN

Electrical Power
Exhaust System
Air Outlets



Under-the floor industrial trench with utility post which can be removed when not needed. Steel plate cover is placed in hole.

APPENDIX G
EXHAUST SYSTEM



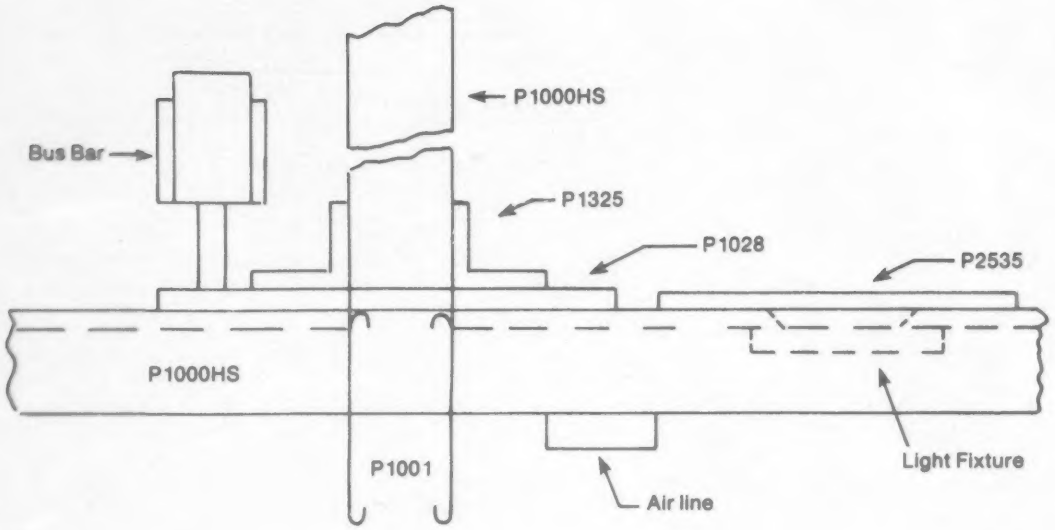
Total dust exhaust system has 7200 cfm.

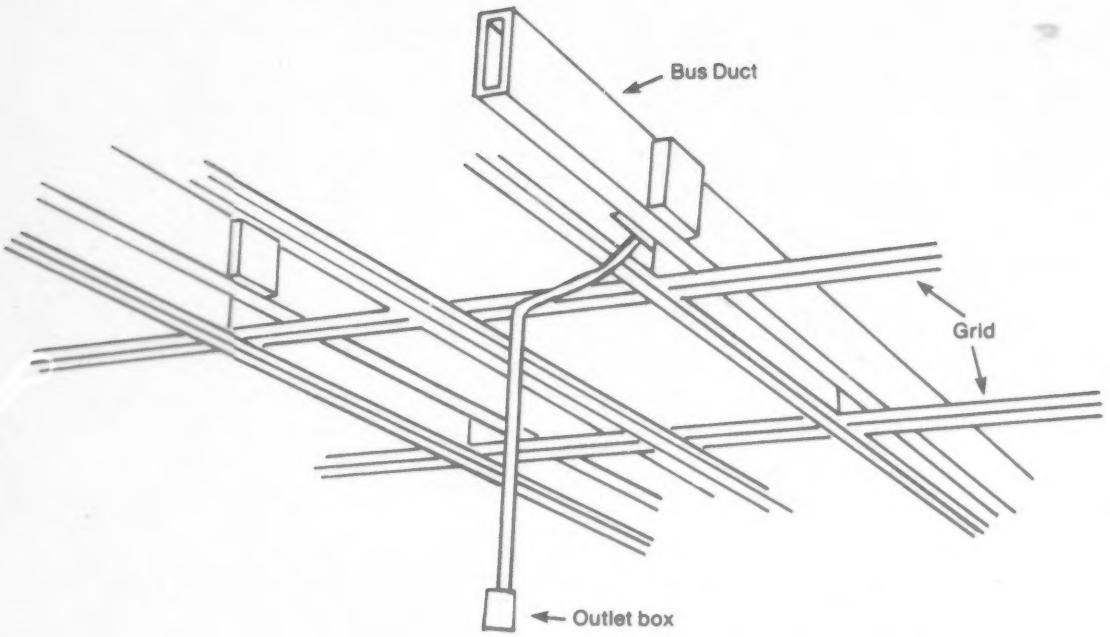
APPENDIX H
EXHAUST SYSTEM SPECIFICATIONS FOR WOODWORKING MACHINES

Machine	Number of Branch Ducts Required	Branch Duct Diameter, in Inches	Branch Duct Air Transport Velocity (cfm)
Circular saw			
Up to 12″ dia.	1	4	350
Over 12″ dia.	1	5	550
Radial saw			
Up to 20″ dia.	1	4	350
Disc sander			
Up to 12″ dia.	1	4	350
12″ to 18″ dia.	1	4½	450
Jointer			
Up to 6″	1	4	350
6″ to 12″	1	5	550
Surfacer			
Up to 20″ width	1	6	775
20″ to 26″ width	1	7	1,050
Vertical belt sander			
Up to 6″ width	1	4½	450
6″ to 9″ width	1	5	550
Lathe	1	4½	450
Scroll saw	1	4	350
Bandsaw	1	4	350
Horizontal belt sander			
Up to 6″ wide	1	4½	450
6″ to 9″ wide	1	5	550
Shaper, wood	1	5	550

Floor sweep—Use 6″ branch duct for fine dust & 8″ for coarse.

APPENDIX I
UNISTRUT GRID SYSTEM





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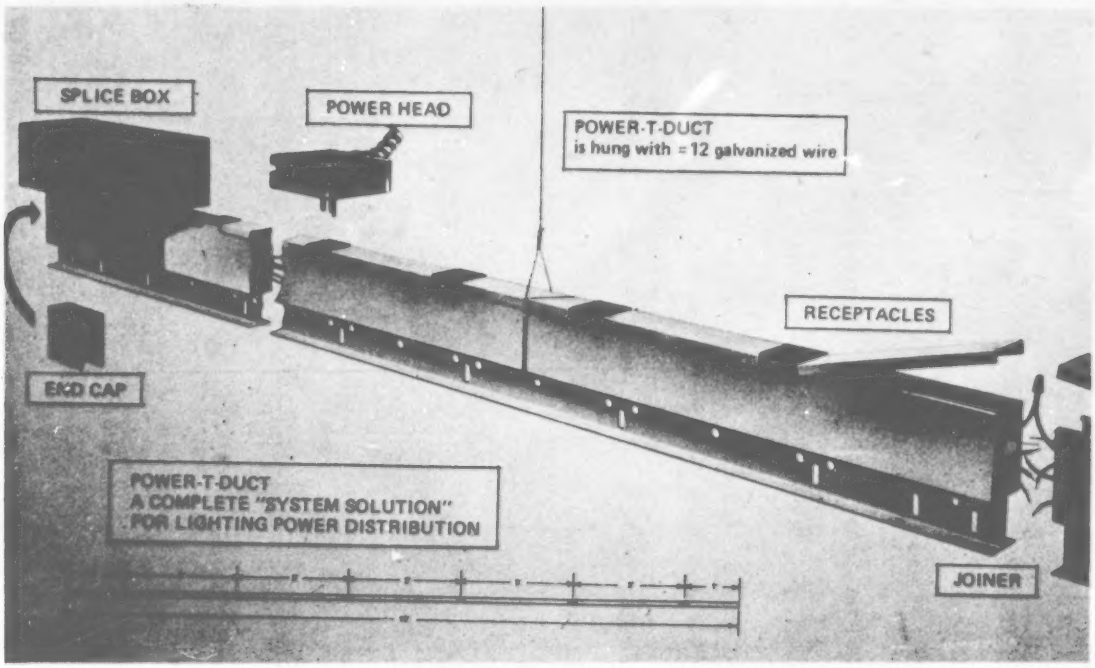
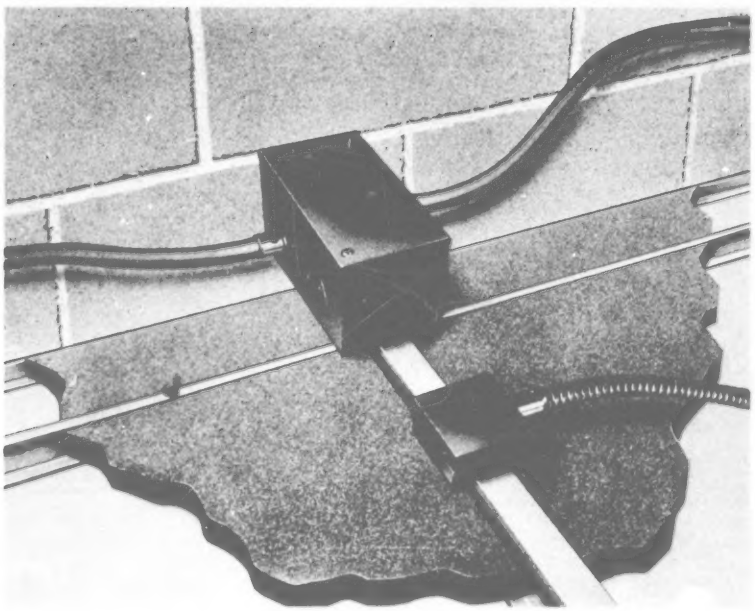
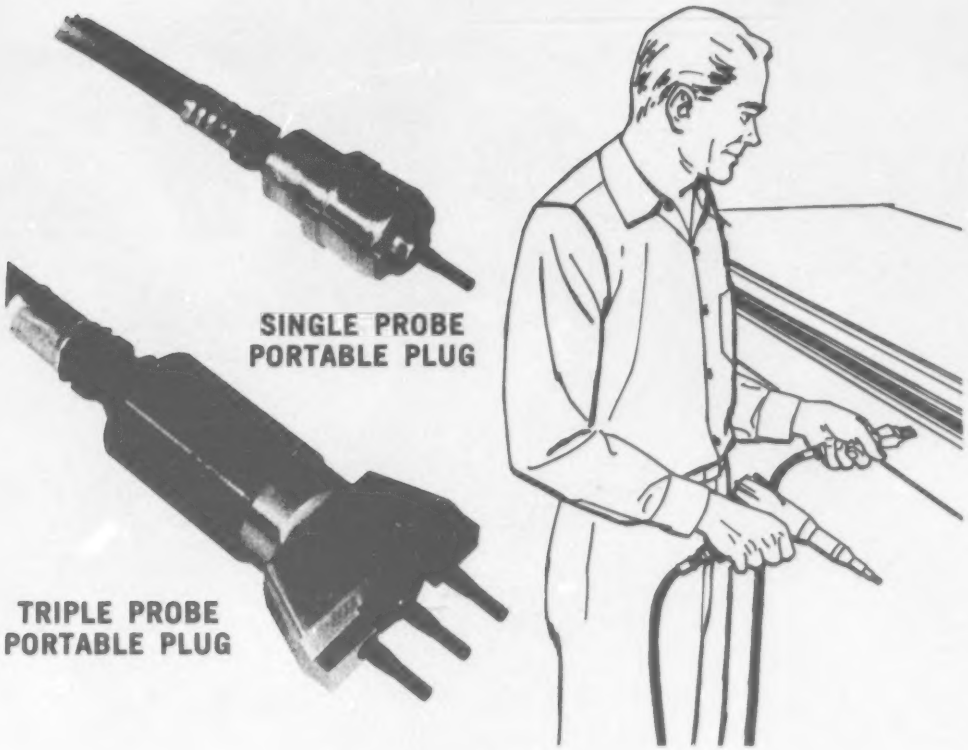




APPENDIX J
POWER-T-DUCT ELECTRICAL SYSTEM

The Power-T-Duct System provides for flexibility and is easily adapted to many machines. It provides for multiple power hook-ups and voltages. Lightweight and small for easy installation. Microflector Co., Inc. Inwood, Long Island, New York 11696.

APPENDIX K
CONTINUOUS AIR SYSTEM



The continuous air system provides the flexibility of multiple air connections from anywhere along the air line. One gauge will serve the entire line and permit different size probe plugs to be used for variable air distribution and higher volume. Gardner-Denver Co., Quincy, Illinois 62301